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Ministry of Transportation
Materials Engineering and Research Report

Aggregate and Soil Proficiency Sample Testing Program for 2004

MERO-015

Technical Report Documentation Page

Publication Title	**Aggregate and Soil Proficiency Sample Testing Program for 2004**
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Originating Office	Materials Engineering and Research Office, Ontario Ministry of Transportation
Report Number	MERO-015; ISBN 0-7794-7552-6
Publication Date	January, 2005
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Abstract	The Materials Engineering and Research Office, Soils and Aggregates Section, runs a proficiency sample testing program each year to provide a means for participating laboratories to see if they are performing satisfactorily. We also conduct a sample-testing program along with our annual proficiency program, for laboratories to measure their ability to perform tests related to Superpave aggregates. The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected at the MTO Laboratory. The samples are delivered to the participating public and private sector laboratories, starting in June and they report their results for annual proficiency sample tests starting in the early part of August. A preliminary report issued in mid September allows the laboratories to examine their procedures or equipment and correct any problems that may have occurred. This is the final report for both, the Aggregate and Soil Proficiency Samples and Superpave Consensus Property Testing for 2004. This year there were two hundred and eight laboratories participating from the private and public sector in the Aggregate and Soil Proficiency Sample Testing Program. Participation in the Superpave Consensus Property Testing Program is voluntary. Forty-one laboratories from the private sector and MTO Downsview laboratory reported results for this program. Results of the 2004 Proficiency Sample Program are found to be consistent with the results reported in the last three years but in some of the tests, the variations show noticeable improvements compared to previous years' results. Although there is noticeable improvement in results, strong laboratory biases still remain in many of the test procedures. The variations in the results for consensus property testing program are close to the values published in ASTM precision statements, except for the uncompacted void content test, where there is a need for further improvement. Our laboratory rating system that was devised in 1997 was used to rate the participants in both programs. The rating system has acted as an incentive for laboratories to improve their performance.
Key Words	Aggregate, consensus property, correlation, laboratory, proficiency testing, soil, Superpave
Distribution	Unrestricted technical audience.

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106-07204/

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Executive Summary

The Soils and Aggregates Section of the Materials Engineering and Research Office, runs an annual proficiency sample-testing program for aggregate and soil tests. This provides a means for participating laboratories to see if they are performing satisfactorily. The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected by the Soils and Aggregates Laboratory. The samples are delivered to the participating laboratories starting in June. The laboratories report their results starting in August. A preliminary report issued in mid September, gives feedback to the participants while they are still operational in the current year. This allows them to examine their procedures or equipment and correct any problems that may have occurred. A final report is issued after analysis of the data has been completed.

In addition to our annual correlation program, the Soils and Aggregates Section is conducting a proficiency sample-testing program for laboratories to measure their ability to carry out tests related to Superpave Aggregate Consensus properties. This is conducted along with the MTO Aggregate and Soil Proficiency Sample Testing Program. The participants in consensus property tests are requested to perform four tests on the same aggregates that are supplied for the annual correlation program. The laboratories report their results for this program in early October.

This is the final report for the 2004 MTO Aggregate and Soil Proficiency Sample Testing and the Superpave Aggregate Consensus Property Testing Programs. This year, there were two hundred and eight (208) laboratories from the private and public sector participating in the Aggregate and Soil Proficiency Sample Testing Program. Of these, one hundred and forty were aggregate producer's and road builder's Quality Control (QC) Laboratories. The remainder were engineering testing consultants and owners laboratories. Participation in this program is required by the contract documents if contractors QC process is to be acceptable to MTO. In general, these laboratories are conducting particle size analysis, wash pass 75 μm, percent crushed particles, percent asphalt coated particles, and density tests for granular base and sub-base aggregates.

Participation in the Superpave Aggregate Consensus Property Testing Program is voluntary. Forty-two laboratories from the private sector reported results for the program in 2004. The laboratories that participate in this program conduct uncompacted void content of fine aggregate (ASTM C 1252/AASHTO T 304), sand equivalent value of fine aggregate (ASTM D 2419/AASHTO T 176), percent of fractured particles in coarse aggregate (ASTM D 5821), and flat particles, elongated particles, or flat and elongated particles in coarse aggregate (ASTM D 4791) tests related to Superpave aggregate consensus properties.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (*i.e.* a rating of 5 for data within 1.0 standard deviation

of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings for each test method are also used to calculate an overall laboratory rating. This rating system has acted as an incentive for laboratories to improve their performance.

Results of the 2004 Proficiency Sample Program are more or less consistent with results from previous years and in some of these tests, the results show noticeable improvements compared to previous years' results. Particularly, the results of wash pass 75 μm, Los Angeles abrasion, percent flat and elongated particles, amount of asphalt coated particles, relative density and absorption (coarse), percent crushed particles, one-point proctor, magnesium sulphate soundness (fine), freeze-thaw and Micro-Deval (coarse) show improvements over previous years. This is likely due, in part, to laboratory improvements brought about by the Canadian Council of Independent Laboratories (CCIL) inspection program of Aggregate Laboratories. Although there is noticeable overall improvement in results from previous years, strong laboratory biases still remain in some of the test procedures. The variations in soil test results are significantly lower than the values reported in the previous four years of study, but the scatter plots show a strong laboratory bias.

The number of participants in the Superpave aggregate consensus property testing program has risen from twenty in 2002 to forty-two in 2004. Most of the laboratories who, participated in the 2004 Superpave aggregate tests have now gained experience with these test procedures. The variations for all of the tests are close to the values published in ASTM precision statements, except for the uncompacted void content of fine aggregate, where there is need for further improvement. The scatter diagrams for all four tests show strong laboratory biases.

The Soils and Aggregates Section, continues to carry out the on-site inspection of soil-testing laboratories. The on-site inspection program was introduced in September 1999, in an effort to improve the quality of soil and bridge foundation testing services provided to the ministry. This inspection is being done at the request of laboratories. The laboratories that are inspected and accepted for providing services to MTO must request a re-inspection whenever the technician(s) or equipment changes. To date, thirty-seven laboratories have been inspected, of which thirty-one laboratories have been approved to do testing in this field for MTO work.

1. Introduction

This is the final report of an annual inter-laboratory testing program organised by MTO for aggregate and soil test methods. It is primarily intended to provide a means for laboratories used by MTO to see if they are performing satisfactorily and to qualify these laboratories to perform quality control and quality assurance testing for MTO contracts[1]. The design of the testing program is based on procedures for determining the precision and variability of test methods. Interested parties should refer to ASTM C670[2], C802[3], E177[4] and E178[5] for further information on inter-laboratory testing programs.

There were a total of two hundred and eight laboratories participating in the Aggregate and Soil Proficiency Sample Testing Program, conducted in the summer of 2004. The participants were also asked to submit results for Superpave aggregate consensus property tests, if they were equipped to perform the tests. Forty-two laboratories, up from twenty in 2002, submitted results for the tests related to these properties. Participants in both testing programs included the MTO laboratory, the remainder being from the private sector (contractors, aggregate producers and engineering consultants) and municipalities. Samples were delivered to laboratories in June. A preliminary report for Proficiency Sample Testing Program was issued in mid September. This document is the final report for both programs.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (*i.e.* a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings for each test method are also used to calculate an overall laboratory rating. This rating system has acted as an incentive for laboratories to improve their performance.

The ministry has been conducting the proficiency sample testing program since the late 1980's and was using a computer program that was developed in the early 1980's to run on Disk Operating System (DOS). Since 2001, the ministry has added three more aggregate tests and four tests related to Superpave aggregates to the MTO proficiency sample testing program. With the addition of these tests, the participating laboratories have the means to check their performance in twenty-one aggregate tests and three soil tests. In order to incorporate the additional tests and to upgrade the software used for the statistical analyses of test data, a new computer program that is compatible with WIN 2000 was developed.

1 Laboratories must also be inspected and recognised by the Canadian Council of Independent Laboratories (CCIL).
2 ASTM C670 Practice for Preparing Precision and Bias Statements for Test Methods of Construction Materials.
3 ASTM C802 Practice for Conducting an Inter-laboratory Test Program to Determine the Precision of Test Methods of Construction Materials.
4 ASTM E177 Practice for Use of Terms Precision and Bias in ASTM Test Methods.
5 ASTM E178 Practice for Dealing with Outlying Observations.

MTO has been using the new computer program since 2003 (Vasavithasan and Rutter, 2004). This program has two options to detect outlying observations or outliers in a set of data: namely, the Critical Value Method and the Iterative (Jack Knife) Technique. These techniques are based on two different statistical methods and yield confidence intervals depending on the number of observations (number of laboratories participating in a particular test method) and the distribution of data. An outlying observation is one that appears to deviate markedly from the sample population. An outlier may be merely an extreme manifestation of the random variability inherent in the data or may be the result of gross deviation from the prescribed experimental procedure, calculation errors or errors in reporting data. Various statistical methods are available to test the hypothesis that the suspect observations are not outliers.

The Critical Value Method used in the new program is recommended in Section 4 of ASTM E 178. The critical value is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all observations in the sample come from the same normally distributed population. ASTM E 178, Table 1 provides critical values only up to 147 observations, but over 200 laboratories participate in our annual Proficiency Sample Testing Program. The critical values for the development of this program have been calculated at five percent significance level (Grubb's test) based on Grubbs (1950 and 1972) recommendations for identifying outliers. The new program also has the option of using the Jack Knife method, which was also available in the old program.

2. Test Results

2.1 TABLE OF TEST RESULTS

Each participant receives an individual summary of results for their laboratory. An example of a typical report is shown in Tables 1, 2, 3, and 4. Each Table of Results identifies the laboratory by number and compares the laboratory's data with the means obtained after statistical analysis of the data received from all laboratories. The identity of the laboratories is kept confidential.

Column 1 gives the test method as designated in the MTO Laboratory Testing Manual.

Columns 2 and 3 show the test data submitted by the laboratory for a pair of samples.

Columns 4 and 5 show the mean (average) test value for each sample, for all laboratories performing the test, after removal of outliers and/or invalid test data.

Columns 6 and 7 list the standardized deviate for each test result. The standardized deviate is used to show how the individual test results compare to the mean. It is obtained by subtracting the mean of all data ($\overline{X}$) from the actual test result reported by the laboratory (X_i) and dividing by the standard deviation (s). That is:

$$\text{Standardized deviate} = \frac{(X_i - \overline{X})}{s}$$

If the test result is less than the mean, the standardized deviate is negative, and if the test result is greater than the mean, the standardized deviate is positive. In brief, the standardized deviate tells us how many standard deviations the test result is away from the mean.

Columns 8 and 9 list the test method ratings, which are similar to the standardized deviate, but are in a simple numeric form. Ratings are determined as follows:

Rating 5 - data within 1.0 standard deviation of the mean.
Rating 4 - data within 1.5 standard deviations of the mean.
Rating 3 - data within 2.0 standard deviations of the mean.
Rating 2 - data within 2.5 standard deviations of the mean.
Rating 1 - data within 3.0 standard deviations of the mean.
Rating 0 - data 3.0 or more standard deviations from the mean or data considered to be outlying by other methods.

A negative sign simply indicates a result that is smaller than the mean. If one of the paired test results for a given test is excluded based on the outlier criteria, the other test result is still subjected to the statistical analysis and is only excluded if it also fails to meet the criteria.

The outlier criteria employed for exclusion of test results from the analysis will depend on

the distribution of data and the number of participants in a test. The iterative technique is used where the strict application of critical value method recommended in the Section 4 of ASTM E 178, tends to include the data that does not belong to the population. In the critical value method, the standardized deviate of a lab result is compared with the critical value corresponding to the number of participants in that particular test for rejecting an outlier. The critical value is greater than 3 when the number of participants in a particular test method is 30 or more. For this reason, results with more than 3 standardized deviates may not have been identified as an outlier unless it is higher than the critical value, but a zero rating is nevertheless assigned for the test result in question. For example, if the computed standardized deviate for a lab result is 3.236 and the critical value corresponding to the number of participants in that particular test is 3.427, the lab will not be identified as an outlier but a zero rating will be assigned.

Significance need not necessarily be attached to a single low rating. However, a continuing tendency to get low ratings on several pairs of samples or on a series of tests from one procedure, *e.g.* sieve analysis, should lead a laboratory to re-examine its equipment and test procedure. A laboratory that reports data for a specific test consistently lower or higher than the mean over a number of test periods also needs to re-examine their test procedure, because this is evidence of a systematic bias in how the laboratory conducts the procedure. Any computer program that is used by a laboratory to calculate test results should be verified as part of this examination.

2.2 SCATTER DIAGRAMS

Youden scatter diagrams are supplied with this report (see Appendices D1 and D2). A laboratory can locate itself on the diagrams by plotting its test value for the first sample (1.04) on the horizontal axis, against its test value for the second sample (2.04) on the vertical axis. The horizontal and vertical axes are of equal length and are scaled to give the most informative display of the plotted points. In some cases, the outlying results plot off the diagram. If the results from two or more laboratories happen to coincide, a single point is plotted.

Below each scatter diagram, the test number and title are given, followed by a table of statistical calculations for both samples. Here the mean, median and standard deviation for each sample are given. The number of laboratories reporting valid data and the laboratories eliminated by statistical analysis are also listed.

The vertical and horizontal cross-hairs on the plots represent the mean values for all the results on the first sample (1.04) and the second sample (2.04) respectively. These lines divide the diagram into four quadrants, numbered 1 through 4, beginning in the upper right-hand quadrant and continuing clockwise. In an ideal situation where only random errors occur, the points are expected to be equally numerous in all quadrants and will form a circular distribution. This follows because plus and minus errors should be equally likely. Often, however, the points tend to concentrate in quadrants 1 and 3 on the diagram. This

occurs because laboratories tend to get high or low results on both samples. This gives evidence of individual laboratory biases. As the tendency to laboratory bias increases, the departure from the expected circular distribution of points towards a linear distribution from quadrant 1 to 3 occurs. Such a distribution of points indicates systematic variation. Figure 1 gives examples of scatter diagrams.

Table 1. Summary of Results (Laboratory 47)

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 20, 2004					
COARSE AGGREGATE REFERENCE SAMPLES 1.04 & 2.04								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.04	2.04	1	2	1	2	1	2
LS-601 Wash Pass 75 µm (Coarse Aggr.)	0.900	1.000	1.013	1.028	-0.747	-0.213	-5	-5
LS-602 – Coarse Aggregate								
Percent Passing 19.0 mm	98.600	98.500	97.664	97.600	1.720	1.392	3	4
Percent Passing 16.0 mm	90.800	90.000	89.476	89.037	1.045	0.687	4	5
Percent Passing 13.2 mm	81.800	80.600	79.793	78.895	1.096	0.809	4	5
Percent Passing 9.5 mm	67.500	67.000	64.803	63.646	1.353	1.336	4	4
Percent Passing 4.75 mm	50.320	49.610	47.494	46.566	1.448	1.279	4	4
LS-603 Los Angeles Abrasion %	21.120	20.020	21.536	21.275	-0.458	-0.867	-5	-5
LS-607 Percent Crushed Particles	61.300	64.800	69.201	69.717	-1.661	-0.999	-3	-5
LS-608 % Flat & Elongated Particles	9.600	8.500	9.199	8.946	0.108	-0.128	5	-5
LS-609 Petrographic Number (Concrete)	149.00	142.00	150.95	145.27	-0.282	-0.265	-5	-5
LS-614 Freeze - Thaw Loss, %	17.400	16.100	17.464	17.654	-0.017	-0.412	-5	-5
LS-618 Micro-Deval Abrasion Loss (CA)	10.800	10.600	10.529	10.535	0.508	0.122	5	5
LS-620 Accelerated Mortar Bar (14 Days)	0.143	0.326	0.196	0.410	-1.525	-1.642	-3	-3

Blank spaces represent not tested.
* - Calculation considered outlier

Table 2. Summary of Results (Laboratory 47)

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 20, 2004					
FINE AGGREGATE REFERENCE SAMPLES 1.04 & 2.04								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.04	2.04	1	2	1	2	1	2
LS-623								
Maximum Wet Density (g/cm^3)	2.281	2.296	2.280	2.281	0.051	0.377	5	5
Maximum Dry Density (g/cm^3)	2.102	2.122	2.102	2.105	0.011	0.433	5	5
Optimum Moisture, %	8.500	8.200	8.469	8. 479	0.068	-0.569	5	-5
LS-604 – Coarse Aggregate								
Relative Density (O.D)	2.688	2.685	2.687	2.686	0.093	-0.157	5	-5
Absorption	0.410	0.430	0.463	0.470	-0. 818	-0.542	-5	-5
LS-621								
Asphalt Coated Particles, %	40.040	43.790	41.325	40.598	-0.259	0.719	-5	5

Blank spaces represent not tested.
* - Calculation considered outlier

Table 3. Summary of Results (Laboratory 47)

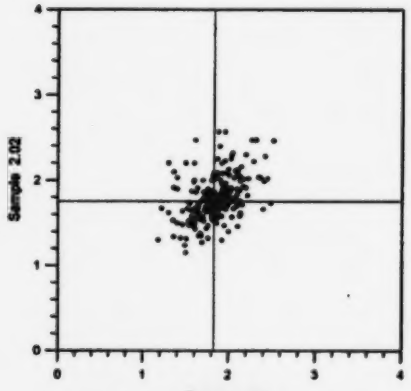
TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 20, 2004					
FINE AGGREGATE REFERENCE SAMPLES 3.04 & 4.04								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	3.04	4.04	3	4	3	4	3	4
LS-605 – Fine Aggregate								
Relative Density (O.D)	2.593	2.589	2.602	2.600	-0.593	-0.570	-5	-5
Absorption	1.760	1.800	1.717	1.719	0.216	0.270	5	5
LS-606 – Coarse Aggregate								
MgSO4 Soundness Loss, %	3.200	2.800	5.399	5.203	-1.098	-1.430	-4	-4
LS-606 – Fine Aggregate								
MgSO4 Soundness Loss, %	14.600	15.100	11.888	11.982	0.597	0.684	5	5
LS-619- Fine Aggregate								
Micro-Deval Abrasion	17.500	17.300	16.597	16.731	0.615	0.393	5	5
LS-611								
Attrition Loss (FA), %								
LS-602 – Fine Aggregate								
Percent Passing 2.36 mm	39.900	39.600	37.232	36.394	1.344	1.550	4	3
Percent Passing 1.18 mm	31.400	30.800	28.412	27.909	1.592	1.447	3	4
Percent Passing 600 µm	21.800	21.600	19.700	19.362	1.378	1.298	4	4
Percent Passing 300 µm	13.600	13.500	12.232	12.035	1.273	1.184	4	4
Percent Passing 150 µm	9.200	9.300	8.296	8.129	1.208	1.292	4	4
Percent Passing 75 µm	7.110	7.100	6.269	6.144	1.398	1.261	4	4

Blank spaces represent not tested.
* - Calculation considered outlier

Table 4. Summary of Results (Laboratory 47)

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 20, 2004					
SOILS REFERENCE SAMPLES 1.04 & 2.04								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.04	2.04	1	2	1	2	1	2
LS-702 – Sieve Analysis of Soil								
Percent Passing 2.00 mm	100.00	100.00	99.983	99.991	-	-		
Percent Passing 425 µm	97.400	97.200	97.133	96.995	0.438	0.335	5	5
Percent Passing 75 µm	92.900	92.200	91.767	91.667	1.193	0.639	4	5
Percent Passing 20 µm	70.500	72.500	78.137	78.489	-2.275	-1. 567	-2	-3
Percent Passing 5 µm	51.000	51.900	59.004	58.770	-1.871	-1. 813	-3	-3
Percent Passing 2 µm	38.500	37.700	44.393	44.596	-2. 098	-2.536	-2	-1
LS-703								
Liquid Limit, %	39.100	39.500	36.897	37.179	1.235	1.322	4	4
LS-704								
Plastic Limit, %	20.300	20.000	19.323	19.177	0.709	0.585	5	5
Plasticity Index, %	18.800	19.500	17.479	18.001	0.615	0.660	5	5
LS-705								
Specific Gravity of Soil	2.770	2.768	2.729	2.733	1.390	1.218	4	4
AGGREGATE CONSENSUS PROPERTIES								
Uncompacted Void Content	42.000	42.200	42.095	41.811	-0.064	0.349	-5	5
Sand Equivalent Value	38.400	38.600	49.961	50.563	-1.430	-1.393	-4	-4
Percent Fractured Particles	59.500	59.800	71.179	71.514	-2.327	-2.338	-2	-2
% Flat & Elongated Particles	2.900	3.100	1.751	1.608	1.039	1.599	4	3

Blank spaces represent not tested.
* - Calculation considered outlier

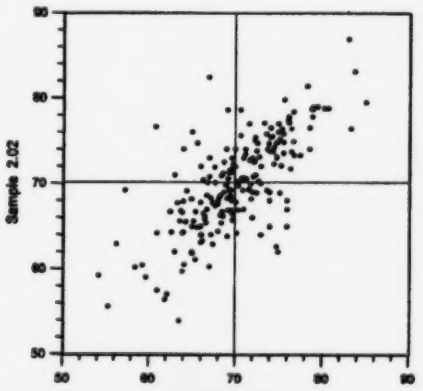


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	1.852	1.779
Median	1.880	1.780
Std Dev	0.250	0.273
n = 204		

Labs Eliminated: 447, 497, 516, 452

Scatter diagram for a test showing random variation with little Laboratory bias

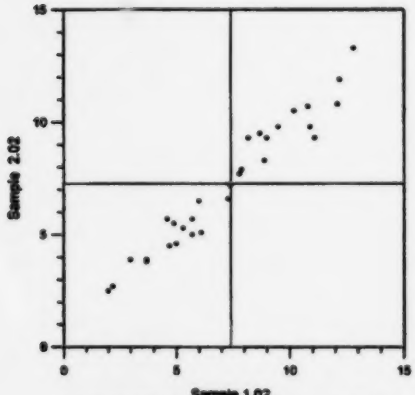


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	69.969	70.208
Median	69.750	70.350
Std Dev	5.568	5.607
n = 188		

Labs Eliminated: 350, 345, 436,460

Scatter diagram for a test showing a combination of random variation and laboratory bias for some Laboratories

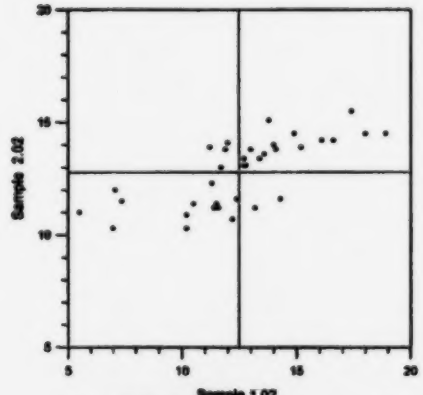


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	7.452	7.363
Median	7.400	7.700
Std Dev	3.245	2.844
n = 31		

Lab Eliminated: None

Scatter diagram for a test showing pronounced between laboratory bias and equal variation for each material



Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	12.586	12.786
Median	12.700	13.100
Std Dev	3.005	3.199
n = 35		

Lab Eliminated: None

Scatter diagram for a test with pronounced between laboratory bias but unequal variation for each material

Figure 1 Examples of Scatter Diagrams

2.3 OUTLIERS

In dealing with suspected outlying observations or 'outliers', our purpose is to remove those observations that do not belong to the sample population and to provide some statistical criteria for doing so. There are a number of ways to do this. In most of these, as ASTM E178 states, 'the doubtful observation is included in the calculation of the numerical criterion (or statistic), which is then compared with a critical value based on the theory of random sampling to determine whether the doubtful observation is to be retained or rejected. The critical value is that value of the sample criterion that would be exceeded by chance with some specified (small) probability on the assumption that all observations did indeed constitute a random sample from a common system of causes, a single parent population, distribution or universe.

The MTO study follows the criteria recommended for single samples in Section 4 of ASTM E 178 for rejecting the doubtful observations at the ninety-five percent confidence level. The critical value method is based on the assumption of normality and the critical values are calculated using Student's t distribution. The assumption in this method is that all the observations come from the same normal population. The doubtful observation is included in the calculation of mean and standard deviation of the population. Then the critical value, T_n, for that observation, n, in question is calculated and compared with the critical value based on the theory of random sampling. The doubtful observation is rejected if T_n is higher than the critical value for the five percent significance level. The outlier is removed from the data set and the iterations are continued until no outliers are detected, and a revised mean and standard deviation are calculated after deleting the outlier. The ratings of the laboratories are determined based on the revised mean, standard deviation and standardised deviate.

In some cases, the strict application of the critical value method tends to include laboratories in the population who are not doing a good job. In those cases, the application of the iterative (jack-knife) technique recommended by Manchester[6] is used. In the iterative technique, the Constant C is computed using Fisher's F distribution, and C depends on the number of participating laboratories. In this technique, an outlying observation is rejected based on a statistical criterion but the confidence interval may vary depending on the number of participants and the distribution of sample population.

In the jack-knife technique, after screening the test results for any errors, the doubtful test result is included in the calculation of mean and standard deviation of the data set. The absolute residual values (actual test result minus the mean) are then computed and test result farthest from the mean by a unit of Cs (standard deviation (s) multiplied by a constant C) is identified as an outlier. One outlier at a time is identified and rejected in a manner similar to that of critical value method.

6 The Development of an Interlaboratory Testing Program for Construction Aggregates, by L. Manchester, Ministry of Transportation, Ontario, Engineering Materials Office Report EM-33, Downsview, December, 1979.

3. Discussion

The following discussion contains general and test-specific comments for the 2004 test period. Where ASTM or AASHTO precision statements are published for a given test, an attempt has been made to compare these with the statistics for this period.

A discussion of statistical techniques is presented in the Glossary of Terms, found in Appendix A.

3.1 NOTES ON MATERIAL SOURCES

Materials used in this test period were as follows:

- Coarse and fine aggregate tests, including Sieve Analysis, Percent Crushed Particles (CA), Petrographic Analysis, Relative Density and Absorption (FA), Moisture Density Relationship, Micro-Deval Abrasion Loss (FA), Magnesium Sulphate Soundness (FA), Uncompacted Void Content of Fine Aggregate, Sand Equivalent Value of Fine Aggregate, and Percent Fractured Particles – Granular 'A' from Kern pit near Woodstock (MTO MAIDB No. W11-045, Lafarge Canada Inc.).
- Coarse Aggregate tests, including Wash Pass 75 µm, Percent Flat and Elongated Particles, Relative Density and Absorption, Magnesium Sulphate Soundness, Micro-Deval Abrasion Loss, Freeze – Thaw, and Percent Flat, Elongated, or Flat and Elongated Particles – HL8 Stone from Orillia Quarry (MTO MAIDB No. O11-154, Georgian Aggregates).
- Fine Aggregate Petrographic Examination – Scalped sand from the Huron Construction pit (MTO MAIDB Number C08-003) 11.5 km east of Chatham.
- Soil tests – Glacial Lake Iroquois deepwater laminated silt and clay from Walker Brothers Vineland I Quarry, N03-023.

3.2 NOTES ON SAMPLE PREPARATION

The material processed for the aggregate tests conforms approximately to a granular 'A' gradation. The aggregate samples were prepared using a large spinning riffler, developed and built by staff at the MTO Downsview Laboratory (refer to Figures 2 and 3 of Report MI-179, February 2000). Twenty-five tonnes of granular 'A' were placed in layers into five separate stockpiles. A bobcat loader was used to fill an aggregate bin with small scoops from each stockpile in turn, in order to minimize sample bias. Material was fed along a conveyor belt to fill 30 identical buckets on a spinning turntable. It was found that 22 to 26

revolutions of the turntable were required to fill each bucket to approximately 30 Kg. This resulted in more homogeneity of the samples than would normally be the case using other techniques. In total, five hundred 30 Kg samples were prepared and randomised for distribution to participating laboratories. The participants were responsible for the preparation of their own fine aggregate samples (3.04 and 4.04) from the two bags of granular 'A' delivered.

The soil was air-dried, processed passing 2.0 mm using a Fritsch Soil Mill Pulverizer, and placed in 20 Kg buckets. Individual scoops were collected from each bucket and placed in a separate container. The material from the container was then transferred to the hopper of a small spinning riffle splitter. The hopper of the spinning riffle used is capable of filling 24 identical 2 Kg containers per run. This method was used to create uniform 20 Kg buckets. The correlation material was then prepared by obtaining representative samples from each 20 Kg bucket using the scoop method. The material collected from the 20 Kg buckets was then transferred to the hopper of the spinning riffle and the 500 g correlation samples were prepared. Then the samples were randomised for distribution to participating laboratories. The use of a spinning riffler ensured that as far as possible, each sample was identical to every other sample. It has been found that this is the best technique for minimising sample bias.

3.3 NOTES ON INDIVIDUAL TESTS

For each test, comments have been made pertaining to the variation illustrated by the scatter diagram. The technique used to test for outliers is stated and where possible, reasons for the outlying observations are offered. It is important to keep in mind that there are many variables influencing laboratory testing.

A summary of the statistical data is presented in the Multi-Laboratory Precision Tables found in the Appendix C. Besides the comparison made to ASTM precision statements, comparison of the variation between test periods is made for each of the tests. Because the materials usually differ from year to year, it is emphasised that the comparison between years should be used only as a guide. It is important to note that the yearly use of different materials will have some effect on the variation exhibited in some tests, while it will have relatively little effect on others. For example, the magnesium sulphate soundness test exhibits increased variation as higher mean loss is reported. A coarse aggregate sample having an average mean loss of twenty percent would likely show more variation than a coarse aggregate sample having an average mean loss of ten percent. On the other hand, a sieve analysis could be performed on those same two aggregates, with the percent passing each sieve and the variation being remarkably similar for the two samples.

3.4 PROFICIENCY SAMPLE TESTS

3.4.1 Wash Pass 75 μm (Coarse Aggregate) – Test No. 1

Two hundred and three laboratories participated in this test. Six outliers were identified and rejected using the critical value method. The standard deviation is significantly smaller than in 2002 and 2003, and the range of values published by ASTM. The scatter diagram shows random variation with little laboratory bias. The laboratories that are identified as outliers or with a zero rating should examine their test procedure more closely.

3.4.2 Sieve Analysis (Coarse Aggregate) – Test Nos. 2-6

These tests represent the coarse aggregate portion of the sample gradation. Tests 20-25 carried out on the material passing 4.75 mm sieve as prepared by the participants (samples 3.04 and 4.04), represent the remainder of the gradation. The data is presented in percent passing format and is compared to precision statements developed in the same format by Vogler and Spellenberg[7].

The samples were prepared with a large spinning riffler that is described in Section 3.2. This method of preparation minimises the sample variation and has resulted in no observable average gradation difference between samples 1.04 and 2.04. The variations found in 2004 for all of the coarse sieves are noticeably higher than that of the values obtained in the past three years, but the standard deviations are comparable to the expected variations given in the ASTM precision statements.

Two hundred and four labs carried out the sieve analysis test. Outliers were eliminated using the critical value method. Successive scatter diagrams show a fairly uniform distribution of points about the mean. Four laboratories had reported results that deviated considerably from the mean.

Possible reasons for outlying observations include factors that impact the measurement process such as sieve condition (state of repair and cleanliness), efficiency of the sieving process and apparatus, initial sample mass, and mass on a given sieve. If your laboratory has performed poorly in this test period, you should inspect your sieves (use CAN/CGSB-8.1-88 or ASTM E-11 as guides) and your sieve shaker(s) thoroughly, and once satisfied that they are in order, perform a sieving efficiency test (MTO Method LS-602, Note 5) to pinpoint any problems.

3.4.3 Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8

Only eleven laboratories participated in this test. Two outliers were eliminated using the

7 Vogler, R.H., Department of Transportation, Michigan, AASHTO Technical Section 1c; T27 and Spellenberg, P.A., AASHTO Materials Reference Laboratory; Unpublished Paper.

critical value method. Considering the number of observations (9) used, the analysis may not yield a meaningful or representative statistical data. The lower left and upper right quadrants together account for nine of the eleven points, which is evidence of strong laboratory biases. This test shows systematic variation, as was found in previous years, but the variation in 2004 is noticeably lower than that of the values found in prior years.

ASTM precision statements for 19.0 mm maximum size coarse aggregate, with percent loss in the range 10 to 45%, give a multi-laboratory coefficient of variation of 4.5%. Therefore, results from two different laboratories should not differ by more than 12.7%. The mean in this test (21.4%) is in the range of values for which ASTM data was established, and comparison indicates that this year's variation (average 5.5%) is reasonably close to that of the value given by ASTM.

3.4.4 Relative Density (Coarse Aggregate) - Test No. 9 and Absorption (Coarse Aggregate) – Test No. 10

Ninety-five laboratories participated in these tests in 2004. Six laboratories in the Test No. 9 and four laboratories in Test No. 10 were eliminated using the critical value method. The variation for each of these tests is slightly lower than the values reported in the 2001 to 2003 studies, and considerably less than the values given in the ASTM precision statements. The latest version of ASTM C 127 – 01 does not provide precision estimate for absorption test. The expected variation shown on the precision table in Appendix C is based on the previous publication C 127 – 88. Majority of the points for both of these tests are located in the lower left (3^{rd}) and upper right (1^{st}) quadrants of the scatter diagrams indicating some laboratory bias.

3.4.5 Magnesium Sulphate Soundness (Coarse Aggregate) – Test No. 11

Thirty-five laboratories performed this test in 2004, and one outlier was selected using the iterative technique. The scatter diagram shows a strong laboratory bias and all the points, with the exception of five, are accounted in the lower left and upper right quadrants. This test has historically shown high coefficients of variation due to the difficulty of maintaining solution of the correct density and insufficient drying by some laboratories. The coefficient of variation in 2004 (34.9%) is significantly higher than in 2002 and 2003, and consistent with the value found in 2001 (37.2%). ASTM precision statements, which report a coefficient of variation of 25% for the percent loss range of 9 to 20. It should be noted that the percent loss for aggregates used in the 2001 (5.0%) and 2004 (5.3%) studies is below the range of values for which ASTM reports the precision statement and a comparison with the ASTM statement is not really appropriate.

3.4.6 Percent Crushed Particles – Test No. 12 and Percent Cemented Particles – Test No. 7

Two hundred and three laboratories performed the percent crushed particles test in 2004. Fifteen outliers were selected by employing the iterative technique. The number of outliers

(15) identified this year is considerably higher than in 2003 (5) and closer to the number of outliers eliminated in 2001 (26) and 2002 (22). Variation is noticeably lower than the values obtained during 1989 MTO workshop[8]. The mean in this test (69.4%) is within the range of values (50% to 75%) for which MTO data was established. The variation in 2004 is also noticeably lower than the values obtained from the 2002 and 2003 studies, and similar to that of 2001. The scatter diagram shows a random variation with noticeable laboratory operator bias. The samples distributed did not contain any cemented particles; therefore the percent cemented particles test was not evaluated this year. ASTM has a very similar test method (D 5821) but has not conducted inter-laboratory studies to determine precision and currently publishes precision data (standard deviation of 5.2% for a mean value of 76.0%) obtained from MTO.

3.4.7 Percent Flat and Elongated Particles – Test No. 13

The determination of a flat and/or elongated particle is dependent on operator skill and judgement in using the measurement tool. The ASTM and CSA procedures use a proportional calliper device to measure the *greatest* length or width to thickness ratio. The MTO procedure previously measured the *mean* length or width to the *mean* thickness (MTO Laboratory Manual Revision 15 and earlier). The MTO procedure (Revision 16 and up) has been modified to agree with the ASTM definition. All participants should be using the latest MTO version of the test.

One hundred and sixty seven laboratories reported test results for this test in 2004. The iterative technique was used to reject seven outliers. The average mean in this test (9.0%) and the standard deviation (3.7%) are higher than the range of values reported in years prior to 2003. However, the coefficient of variation (39.8%) in 2004 is significantly lower than that of the values computed (45.9% to 64.8%) from the 2001 to 2003 studies. Eighty five percent of the points in the scatter diagram are accounted in the lower left and upper right quadrants indicating significant laboratory operator bias. ASTM and CSA do not report precision for this test. In general, laboratories that reported values in excess of 15% or less than 5% should critically examine their equipment and procedure.

3.4.8 Petrographic Number (Concrete) – Test No. 14

The coarse aggregate examined in 2004 was from Lafarge Canada Inc. Kern pit (MTO MAIDB Number W11-045) granular 'A' material.

Analysts from twenty-five laboratories examined samples 1.04 and 2.04 (full fraction), and submitted work sheets showing subdivision according to rock type and quality. Laboratories 13, 80, and 196 used the same analyst. Laboratories 39 and 112 used outdated work sheets. The results are shown in the Appendix E1 and were evaluated by D.A. Williams, MTO Petrographer.

8 MI-134, Determination of Crushed Particles for Test Method LS-607, by Price, Gage and Junor, Ministry of Transportation, Ontario, Engineering Materials Office, Downsview, March 1989, ISBN-0-7729-5558-1.

The samples contained approximately 80% good aggregate (approximately 60% hard carbonate, 10% surface weathered or medium hard carbonate, and 10% silicate rock). Values of good aggregate content of more than 90% were reported by laboratories 22 (2.04 only), 71 (1.04 only), and 112; and of less than 70% by laboratory 59 (2.04 only).

The samples contained approximately 15% fair aggregate (mainly chert/cherty carbonate and soft or slightly shaley carbonate). Values of fair aggregate content of less than 6% were reported by laboratories 22 (2.04 only) and 112 (1.04 only); and of more than 30% by laboratory 59 (2.04 only).

The samples contained approximately 5% poor aggregate (mainly chert/cherty carbonate and shaley carbonate), and less than 1% deleterious aggregate. Values of poor aggregate content of less than 0.5% were reported by laboratories 22 (1.04 only) and 30 (2.04 only); and of more than 10% by laboratory 71 (2.04 only).

The contents of good, fair, poor, and deleterious aggregate noted above indicate that the petrographic number of the material is approximately 150.

A need for laboratories 22, 30, 59, 71, and 112 to modify their rock quality classification system is indicated. In addition, relatively low petrographic numbers were reported by laboratories 38 (1.04 only), 61 (1.04 only), and 260 (2.04 only). The amount of chert/cherty carbonate reported was extremely variable, ranging from 0% (laboratory 112) to more than 20% (laboratory 150).

Based on the work sheet, Laboratory 28 did not perform the petrographic examination on the Granular 'A' samples supplied and was removed from the analysis. The petrographic results submitted by this lab are also not included in Appendix E1. Five laboratories were eliminated as outliers using the iterative technique. The standard deviation in 2004 for Sample 2.04 is almost twice that of Sample 1.04 and is significantly higher than the values reported in 2001.

The similar ASTM standard for this test, C-295, does not report a petrographic number and has no precision statement.

3.4.9 Petrographic Analysis (Fine Aggregate)

The fine aggregate examined in 2004 was sand from the Huron Construction pit (MTO MAIDB Number C08-003) 11.5 km east of Chatham.

Analysts from nine laboratories examined samples 1.04 and 2.04, and submitted work sheets showing subdivision according to rock/mineral type (silicate, carbonate, shale, mica, chert, contamination, and cementation) and sieve size. Laboratories 80 and 196 used the same analyst. The results are shown in the appendix and were evaluated by D.A. Williams, MTO Petrographer.

The samples contained an average (unweighted) of approximately 53% silicate, 34%

carbonate, 8% shale, 1% mica, and 4% chert. Silicate and mica contents increased from larger to smaller sieve sizes; and carbonate and chert contents decreased. Values of silicate content of greater than 65% were reported by Laboratories 37 (1.04 only) and 188; carbonate content less than 25% by Laboratories 37 (1.04 only) and 188; shale content less than 5% by Laboratories 37 (1.04 only) and 188 (1.04 only); mica content greater than 2% by Laboratory 37 (1.04 only); and chert content less than 2% by Laboratories 35, 37, 80, and 196.

A need for all laboratories except 47, 59, 101, and 150 to modify their rock/mineral type classification system is indicated.

The similar ASTM standard for these tests, C-295, has no precision statement.

3.4.10 Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16

Sixty-two laboratories reported results for this test in 2004. The test method requires reporting of control sample results to demonstrate that the testing process is in control. This year, one laboratory reported control sample results outside the established range and the lab was excluded from the analysis. Three outliers were rejected using the iterative technique. The test method (LS-618) for coarse aggregate with a MDA value of 12 gives a multi-laboratory coefficient of variation of 6.4%. The mean in this test was 10.5, and the coefficient of variation of 5.0% obtained in 2004 is consistent with the value published in LS-618 and comparable to the values reported in 2001 study. The scatter plot for this test shows a fairly uniform distribution of points about the mean indicating random variation.

3.4.11 Freeze-Thaw Loss – Test No. 17

Forty-eight laboratories reported results for this test. The test method requires reporting of laboratory control sample losses to demonstrate that the testing process is in control. This information is used to alert the laboratory to testing deficiencies. Without testing of the reference material, the test is invalid (see LS-614, section 9.1). This year, all the laboratories reported control sample data within the established range, and no lab was excluded from the analysis. One outlier was selected using the iterative technique. Variation is considerably higher than the multi-laboratory precision statements published in LS-614, but the coefficient of variation (21.4%) is within the range of values (19.8% to 27.0%) reported in 2001 to 2003 studies. The scatter diagram shows evidence of a strong laboratory bias for this test. It is likely that there are two main reasons for the wide spread in data: insufficient damage caused by freezing which is due to freezing too rapidly or difference in sieving intensity. Laboratories should modify their processes to try and achieve losses closer to the mean loss of the control aggregate. LS-614, Revision 22 (Appendix 1) in the MTO Laboratory Testing Manual gives a procedure for determining and adjusting sieving time for quantitative analysis. It is possible that increased use of this procedure to adjust sieving time might have a positive effect.

3.4.12 Sieve Analysis (Fine Aggregate) – Test No. 20-25

The samples for this procedure were prepared by the participants from the material passing the 4.75 mm sieve of the coarse aggregate gradation. This process closely follows the normal testing procedure in which the laboratory prepares its own test samples from the field sample. The scatter diagrams for the fine aggregate sieve analysis show random variation with little laboratory bias. The standard deviations for these tests (Test No. 20 to 25) in 2004 are almost similar to that of 2003 study, and are considerably higher than the values published in ASTM. As in previous inter-laboratory studies, it was found that the precision of the test varies as a function of the amount of material retained on any sieve. The smaller the amount of material retained on the sieve, the more efficient the sieving process, and the better the precision. When there is a small amount of material on a sieve (one layer of particles or less), the particles have a greater chance of falling through the sieve in a given time.

Altogether, three outlier laboratories were selected using the critical value method. Outlier labs with very low percent passing the 75 μm sieve should inspect their sieves, as low percent passing may be the result of the sieve being blinded when washing the sample. An ineffective washing process will also result in a low percent passing the sieve.

3.4.13 Relative Density (Fine Aggregate) – Test No. 27 and Absorption (Fine Aggregate) – Test No. 28

Ninety-three laboratories performed these tests in 2004. The scatter diagrams for these tests show systematic variation. Eleven outliers for Test No. 27 and ten outliers for Test No. 28 were selected using the critical value method. As in previous years, greater variation exists in this test compared to the relative density test on coarse aggregate. It is thought that the differing technique in arriving at the saturated surface dry condition (towelling for coarse aggregate vs. air-current drying and continuous stirring for fine aggregate) is responsible for this variation. It is imperative that differential drying of the various sized particles be avoided by *constant* stirring of the sample under the air current during the drying process. As short as 30 seconds periods of rest can be detrimental for the outcome of the test results. Differential drying of the particles is known to cause premature collapse in the cone test used to judge the saturated surface dry state. The resulting test observations are lower relative densities and higher absorption values. The variation for relative density in 2004 is slightly higher than the values reported in prior years, but the multi-laboratory variation is significantly less than the variation stated in ASTM C128.

The ASTM precision statements, which report a standard deviation of 0.23 for materials with absorption, value less than 1%. The mean for this test (1.718%) is almost twice that of the mean for which the precision statement was published. However, the coefficient of variation (11.1% and 17.5%) in 2004 is slightly less than that of ASTM value (23%). The scatter diagrams for both tests indicate a strong laboratory bias.

3.4.14 Magnesium Sulphate Soundness (Fine Aggregate) – Test No. 29

Thirty-three laboratories participated in this test in 2004. No outlier was detected using the critical value method or iterative technique. All the data, with the exception of two, are accounted in the lower left (quadrant 3) and upper right (quadrant 1) with the axis of scatter of points at approximately 45 degrees. As in previous years, the scatter diagram shows strong laboratory bias. The mean in this test is 11.9%, which is reasonably close to the mean loss reported in 2003 (14.2%). The variations found in 2004 are similar to that of 2003.

3.4.15 Amount of Asphalt Coated Particles in Coarse Aggregate – Test No. 30

This test was first included in the study in 2001 and we have limited information to compare the results. Two hundred and two laboratories reported results for this test in 2004. Six laboratories were selected as outliers using the critical value method. The scatter plot shows random variation with some laboratory bias. The variations in 2004 are consistent with the values reported in 2003. There is no comparable or similar ASTM test procedure, and no precision statement has been established by MTO. Laboratories, which reported values of less than about 35% and above 47%, should critically evaluate their interpretation of the definition and re-examine their samples.

3.4.16 Moisture-Density Relationship (One-Point Method) – Test Nos. 31-33

One hundred and forty one laboratories reported results for this test procedure. Eight outliers for Test No 31 and five outliers for Test No. 32 were rejected using the critical value method. The variations in 2004 are noticeably smaller than the values reported in 2003 study and comparable to that of 2001 and 2002. Majority of the points in the scatter diagrams are located in the lower left and upper right quadrant of the plots with strong laboratory bias showing testing rather than the material variability is the source of the errors. The possible causes for the bias may be operator error and the use of an improper mould even though the participants were requested to use only the 152.4 mm diameter mould. This test also requires significant operator skill to obtain the point within the band in the first attempt. Those laboratories with poor ratings should examine their equipment and procedure to discover the causes for this variation. There is no ASTM precision statement for this test.

3.4.17 Micro-Deval Abrasion (Fine Aggregate) – Test No. 34

Participants were asked to prepare their own test sample from the bulk sample provided. Sixty-two laboratories participated in this test in 2004. The test method requires reporting of control sample test results to demonstrate that the testing process is in control. One laboratory reported control samples outside the established range. The scatter diagram shows a combination of random variation and laboratory bias. One outlier was selected using the critical value method. The standard deviation (1.5) and the coefficient of variation (8.8%) are noticeably higher than the multi-laboratory coefficient of variation (5.6%) published in the test method (LS-619) and values found in previous years.

3.4.18 Accelerated Mortar Bar – Test No. 123

In the past, Soils and Aggregate Section used to conduct a separate multi-laboratory study for accelerated mortar bar expansion test. This test was included first time in our annual Proficiency Sample Testing program and sixteen laboratories participated in 2004. The participants were asked to prepare a sample of fine aggregate from Granular 'A' sample (1.04) distributed for 2004 program and to carry out one test with this aggregate. The participants were also asked to test three mortar bars made with the Spratt control aggregate at the same time. The use of standard cement to improve the multi-laboratory precision is found to be not worthwhile (Rogers, 1999). With this in view, standard cement was not specified for this study and the participants used their own cement.

The participants reported expansion of the individual bars and the average of three bars after 7, 13, 14, 15, 21 and 28 days in NaOH solution. Only the average expansion after 14 days was analysed and shown on the scatter diagram in the Appendix D1. The scatter diagram indicates a strong laboratory bias, which results from the laboratories that report high expansion value for Spratt control aggregate tends to get a high value for the natural sand. The mean expansion at 14 days obtained from this study 0.410% for Spratt is similar to that of the value reported 0.417% for Spratt in the Rogers (1999). Rogers (1999) also suggest that the multi-laboratory standard deviation is proportional to the amount of expansion. The variation found in 2004 for natural sand (17.8%) and Spratt (12.4%) with an overall average variation of 15.1% are consistent with the findings by Rogers (1999), and the precision statement published by ASTM.

3.4.19 Particle Analysis of Soil – Test Nos. 40-45

Sixty-seven laboratories reported results for the hydrometer test in 2004. Test 40 is reported for information purposes only, because 90% of the participants reported 100% passing 2.00 mm. Outliers were selected using the iterative technique. Participants were requested to perform the test according to MTO LS-702, Revision No.19 and to verify this, they were asked to submit the data sheet. Based on the data sheet, four laboratories did not perform the test in accordance with test procedure and the labs were excluded from the analysis.

The scatter diagrams show significant laboratory biases, especially in the case of percent passing 5μm and 2μm. The standard deviations for each of these particle sizes are more or less similar to the values reported in the 2001 to 2003 studies.

The laboratories that are identified as outliers should examine their equipment and procedure very carefully to make certain all is within specification and the procedure is followed exactly.

3.4.20 Atterberg Limits of Soil – Test Nos. 46-48

Seventy-seven laboratories reported Atterberg Limits for the soil samples distributed in 2004. Altogether four outlier laboratories were identified using the iterative technique. The

scatter plots for both Liquid and Plastic Limits show strong laboratory bias. This variation is characteristic of tests that require significant operator skills, and good condition and calibration of the apparatus. The standard deviation for the liquid limit test has always been higher than for the plastic limit, and the same trend is also reflected in the results of 2004. Close attention to the condition and calibration of the liquid limit apparatus and employing skilled technicians may reduce these biases.

The variations found for all three tests in 2004, i.e., liquid, plastic limits, and plasticity index are more or less similar to the values reported in 2001 to 2003 studies. The standard deviations for all three tests are generally higher than the values published in ASTM indicating there is still a need for significant improvement in this testing.

3.4.21 Specific Gravity of Soils – Test No. 49

Sixty laboratories reported results for this test. The participants were requested to perform the test on a minimum of three specimens in accordance with the procedures described in Section 7.1of MTO LS-705, Revision No. 20. They were asked to submit the data sheet to verify if the range, i.e., the difference between the largest and smallest value, is within the limit specified (0.02) in the test method. Based on the data sheet, six laboratories exceeded the limit and were excluded from the analysis. Four outliers were also detected using the iterative technique. The scatter plot shows strong laboratory bias. Several steps in this test procedure can influence the results. Particularly, the equipment and method employed for preparation of test specimen as well as for removal of air entrapped in the pycnometer or flask. The possible cause for the bias may be because the laboratories do not fully comply with the test procedures. Laboratories finding themselves in this situation should examine their equipment and procedure very carefully.

The test method MTO LS-705 is similar to that of AASHTO T 100, which reports a standard deviation of 0.04. The standard deviation obtained in 2004 is considerably lower than the value published in AASHTO T 100. In 2003, we did not reject any laboratory for exceeding the range specified in the test method or as an outlier.

3.5 SUPERPAVE CONSENSUS PROPERTY TESTS

3.5.1 Uncompacted Void Content (FA) – Test No. 95

The participants were asked to prepare the fine aggregate by splitting the material passing 4.75 mm sieve. The participants were advised to perform the test in accordance with Test Method A, i.e., standard graded sample. Forty-one laboratories submitted results for this test. Six laboratories were identified as outliers using the iterative technique. All of the points in the scatter diagram, with the exception of two, are located in the first and third quadrants of the plot showing a strong laboratory bias.

The standard deviations in 2004 are slightly less than the values that were reported in 2003 and are considerably higher than the values published in ASTM for graded standard sand (0.33%). The estimates of precision in ASTM are based on graded sand as described in ASTM C 778, which is considered rounded and is graded from 600 µm to 150 µm, and may not be typical of the samples that were supplied for this testing program. The finer portion (passing 4.75 mm sieve) of the aggregate samples that we have been using for the proficiency program are similar to that of manufactured fine aggregate for which ASTM reports a standard deviation of 1.1%. The variations found from the studies in 2003 (1.62% and 1.35%) and 2004 (1.48% and 1.1%) are closer to the values published for manufactured fine aggregate, i.e., Test Method C – As Received Grading. The bulk dry relative density values reported range from 2.374 to 2.722, and differ by 0.348. The ASTM C 1252 suggests that a difference in relative density of 0.05 will change the calculated void content by about one percent. The number of participants in this test has risen from 20 in 2002 to 41 in 2004. Poor performance in this test by many labs is probably due to lack of familiarity with this test procedure that was recently introduced by most of the participants in their laboratories.

3.5.2 Sand Equivalent Value of Fine Aggregate – Test No. 96

The participants were asked to prepare the fine aggregate by splitting the material passing 4.75 mm sieve. Two alternate procedures for the preparation of test specimen (air-dry or pre-wet) are allowed in both ASTM and AASHTO Methods. The participants were given the option of preparing the test specimen in accordance with either method.

Thirty-eight laboratories participated in this test in 2004 compared to eighteen in 2002. No outlier was identified by the critical value method or iterative technique. The lower left and upper right quadrants of the scatter diagram together account for 95 percent of the points showing significant laboratory bias. The standard deviations for both samples in 2004 (8.1 and 8.6) are significantly higher than values reported in 2002 (2.62) and 2003 (3.51), but the values are consistent with the multi-laboratory precision value published by ASTM for samples with sand equivalent value less than 80. The ASTM precision statement indicates that there are no significant differences between the two methods, i.e., AASHTO T 176 and ASTM D 2419.

3.5.3 Percent of Fractured Particles in Coarse Aggregate – Test No. 97

The samples supplied did not contain adequate material retained on 19.0 mm sieve. Because of this, the participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only.

Forty-two laboratories submitted results for this test in 2004. The number of participants in this test has risen by 22 since 2002. No outlier was detected using the critical value method or iterative technique. The scatter diagram shows a random variation with strong laboratory bias. The mean and standard deviations of the ASTM test (71.3% and 5.0%) are slightly higher than that of the MTO version of the test on the same aggregate (69.4% and 4.8%). The ASTM test method is very similar to MTO LS-607, but ASTM has not conducted inter-laboratory studies to determine precision and currently publishes statistical data obtained by MTO. The variation in 2004 study (5.0%) is consistent with the value (5.2%) published in ASTM precision statements.

3.5.4 Percent Flat and Elongated Particles in Coarse Aggregate – Test No. 99

The samples supplied did not contain adequate material retained on 19.0 mm sieve. Because of this, the participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only using a ratio of 5:1.

Forty-two laboratories performed this test in 2004. One of the participants in this test reported zero percent flat and elongated particles. Two outliers were detected using the iterative technique. The scatter diagram shows a strong laboratory bias. There is no ASTM precision statement for this test.

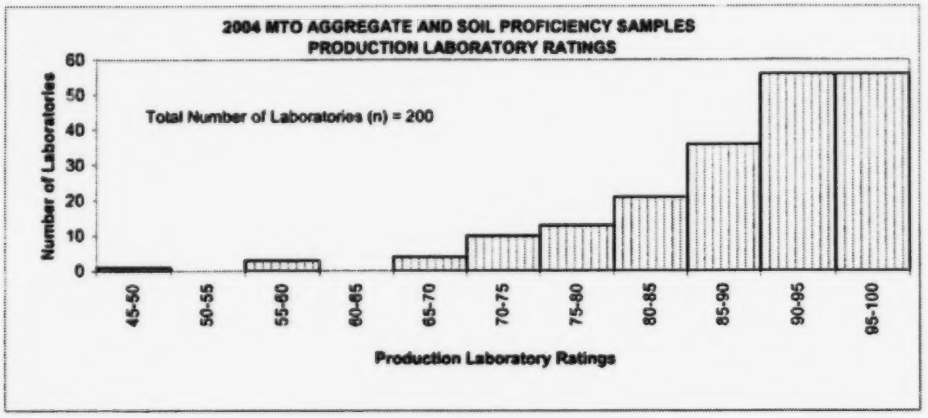
4. Laboratory Rating System

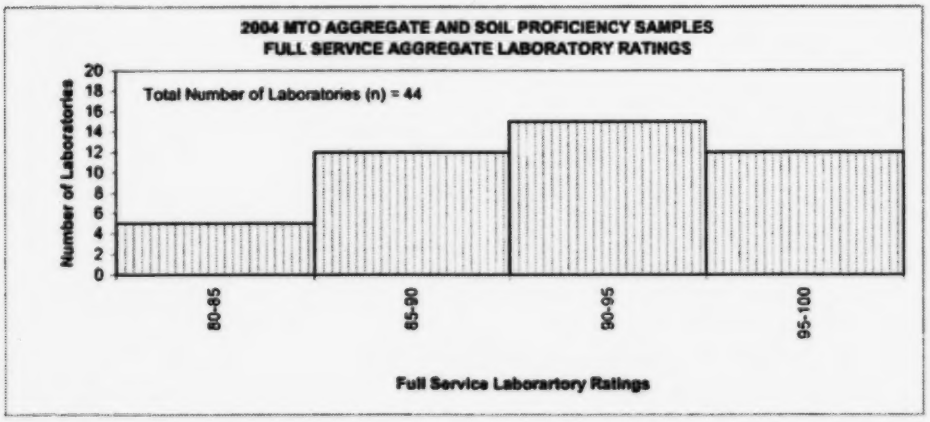
The laboratory rating system, applied to all participating laboratories, was devised in 1997. The rating system assigns separate laboratory ratings for low complexity (production) aggregate laboratories, high complexity (full service) aggregate laboratories, and for soil laboratories. Low complexity laboratories are required to carry out wash pass 75 μm, gradation, percent crushed particles, percent asphalt coated particles, and optional, percent flat and elongated particles. In addition to those low complexity tests, high complexity laboratories must carry out micro-Deval (coarse and fine), freeze-thaw and/or magnesium sulphate soundness, relative density and absorption (coarse & fine). Forty-four (44) high complexity (full service) aggregate laboratories participated in the program in 2004. Soil laboratories are required to carry out particle size analysis, Atterberg limits and specific gravity of soil. Fifty-eight (58) laboratories participated in all three tests, i.e., hydrometer, Atterberg limits and specific gravity, in 2004.

A similar laboratory rating system is also used for assigning laboratory ratings for Superpave aggregate laboratories. The laboratories are required to perform all four tests, i.e., uncompacted void content of fine aggregate, sand equivalent value of fine aggregate, percent fractured particles in coarse aggregate, and flat and elongated particles in coarse aggregate. Thirty-eight of the forty-two laboratories have submitted results for all four tests.

The rating system gives a maximum of 10 for each test, *e.g.* 5 for wash pass 75 μm on sample 1.04, plus -5 for wash pass 75 μm on sample 2.04, equals 10 (the negative sign indicating a test result less than the mean is ignored). Some tests that are normally reported together are averaged and given a maximum of 10. The relative density and absorption (coarse and fine), one-point Proctor values (maximum wet and dry density, and optimum moisture content), particle size analysis of soils and Atterberg limits are treated in this manner. Because of the large number of individual test ratings in the gradation results, the ratings are modified so as not to unduly bias the overall balance between various tests. The ratings for each sieve size are added and then divided by the number of sieves for which results were reported, and multiplied by 3 to give a laboratory rating with a maximum of 30 for this test. Aggregate, soil, and Superpave laboratory ratings are given in Figure 2 and 3. The laboratory rating system data is reported in the Appendices F1, F2, F3, and F4.

Laboratory ratings are given in the covering letter accompanying this report to individual laboratories. A poor or good rating for a laboratory in one year is an indication of how that laboratory performed in the proficiency study, and may not be a reflection of how the laboratory performs year round. A consistently poor rating over two or more years may be cause for serious concern.





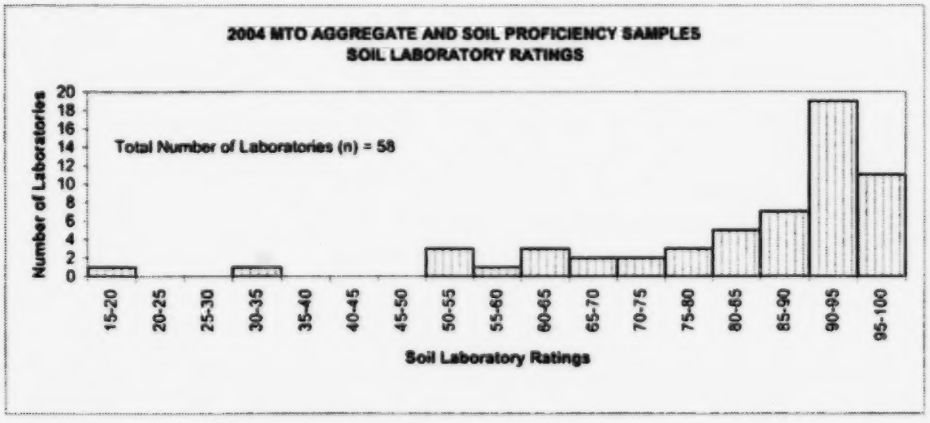


Figure 2 Laboratory Ratings

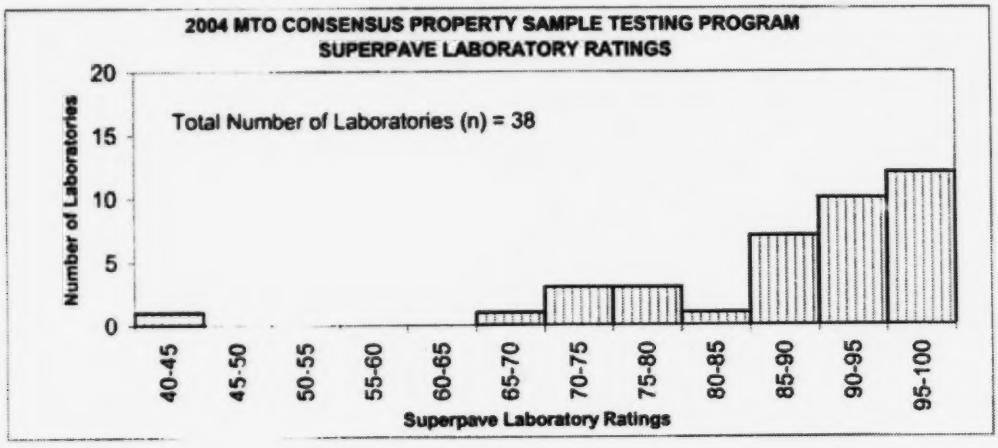


Figure 3 Superpave Laboratory Ratings

5. Conclusions

The samples for this sample-testing program were prepared with a large spinning riffler developed by MTO staff in 1999. This method of sample preparation resulted in no significant (coarse and fine aggregate) mean gradation differences between samples 1.04 and 2.04. In fact, the multi-laboratory variations for gradation test results since 1999 are similar or significantly lower than the variations given in the ASTM precision statements. The differences in mean as well as in variations between pairs of samples for both, coarse and fine sieves, are none to negligible. Based on the results, it may be concluded that the sample preparation method employed is very effective and capable of producing a uniform material at reasonable cost.

The majority of the aggregate and soil test results of the 2004 Proficiency Sample Testing Program compare favourably but also in some cases show noticeable improvement over previous year's results. The variations in most of the tests are more or less similar to the values reported in the last four years. The scatter diagrams for majority of the aggregate tests show either random variation or a combination of random variation and laboratory bias for some laboratories. The tests that show improvement in precision include the wash pass 75 μm, Los Angeles abrasion, percent flat and elongated particles, amount of asphalt coated particles, relative density and absorption (coarse), percent crushed particles, one-point proctor, magnesium sulphate soundness (fine), freeze-thaw and Micro-Deval (coarse).

One hundred and ninety five of the laboratories participated in the aggregate tests are CCIL Type C (low complexity tests) certified and forty-two of those are certified for high complexity tests (Type D). CCIL inspects the certified laboratories for quality control procedures, ability of technicians, and condition and calibration of the equipment at about eighteen months intervals. The aggregate tests are probably showing improvement, in large part, due to the CCIL laboratory inspection and certification program, and due to an increased awareness of the importance of proper testing.

The variations found in 2004 for all three soil tests are lower than the values reported in the last three years' studies, but the scatter diagrams still show strong laboratory biases. The results of soil tests are significantly influenced by the operator skills, testing environment, and the condition and calibration of the equipment. In Ontario, only the laboratories that provide soil-testing services to the ministry are required to participate in the MTO lab inspection program. Twenty-eight of the fifty-eight laboratories participated in the soil tests do not participate in the on-site inspection program. Most of the laboratories that are in the MTO Vendors list were inspected about four years ago and little re-inspection has been done to date. The MTO inspection program is voluntary and there is no affordable inspection or certification program similar to that of CCIL in place for soil testing laboratories to participate. The soil laboratory inspection process that is being carried out by

MTO[9] may have to be extended to all participants in these tests to bring about improvements in variation and to minimise laboratory biases.

The variations in the consensus property test results are reasonably close to those published in ASTM precision statements. However, the scatter diagrams show strong laboratory biases. Most of the laboratories participated in this program have limited experience in these test procedures. The laboratory inspection program for these tests introduced by CCIL in 2003 should bring about improvements in variation and reduce laboratory biases.

9 To arrange an inspection of your Soil Laboratory, please contact Mark Vasavithasan, Soils and Aggregates Section, Ministry of Transportation, phone (416) 235 – 4901, fax (416) 235 – 4101.

6. Recommendations

Although, there are some noticeable reductions in multi-laboratory variation, strong laboratory biases still remain in number of test procedures. The laboratories that were identified as outliers and or obtained zero ratings should examine the condition and calibration of equipment, testing procedures, and skills of the technicians. It is good practice to do this whenever a rating of 2 or less is obtained.

The results of the 2004 MTO Aggregate and Soil Proficiency Sample Program suggest that most laboratories have satisfactory within-laboratory precision, but the multi-laboratory precision needs to be improved for a number of tests. The laboratories must focus on operator training, standardization and calibration of equipment, and laboratory environment in order to improve the multi-laboratory precision.

For all of the tests that were included in this study, the equipment to be used is regulated by the test method itself. A good state of maintenance, repair and correct calibration are sometimes lacking. It is hoped that the Quality System implemented by CCIL in the spring of 2002 will encourage laboratories to conduct self-examination to ensure they have the correct equipment and properly trained technicians. Laboratories will find that a well-documented and regular program of internal inspection, calibration, and testing of control or reference samples, are beneficial to maintaining a high level of confidence in their results.

7. Acknowledgments

The authors wish to acknowledge the assistance and dedicated work of the laboratory staff of Soils and Aggregates Section in preparation of samples and performing the tests. We received considerable assistance from the laboratory staff of Bituminous Section and Concrete Section in preparation of correlation samples for distribution.

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Appendix A: Glossary of Terms

Precision refers to the degree of mutual agreement between individual measurements on the same material. In other words, precision is a measure of how well the individual test results of a series agree with each other.

Accuracy refers to the degree of mutual agreement between a set of measurements with an accepted reference or 'true value.' This 'true' or reference value can be an assigned value arrived at by actual experiments.

Bias of a measurement process is a consistent and systematic difference between a set of test results derived from using the process, and an accepted reference value of the property being measured. For the majority of aggregate and soil tests there is no acceptable reference material, so bias is impossible to compute.

Critical Value is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all the observations did indeed constitute a random sample from a common system of causes.

Coefficient of Variation expresses the standard deviation as a percentage of the mean, where:

$$C.V. = \frac{\text{std dev}}{\text{mean}} \times 100$$

Single operator precision (one-sigma limit (1s)) indicates the variability, as measured by the deviations above and below the average, of a large group of individual test results when the tests have been made on the same material by a single operator using the same apparatus in the same laboratory over a relatively short time.

Multi-laboratory precision (one-sigma limit (1s)) is a quantitative estimate of the variability of a large group of individual test results when each test has been made in a different laboratory and every effort has been made to make test portions of the material as nearly identical as possible. Under normal circumstances the estimates of the one-sigma limit for multi-laboratory precision are usually larger than those for single operator precision because different operators and different equipment are being used in different laboratories.

Acceptable difference between two results (difference two-sigma limit (d2s)) as an index of precision is the maximum acceptable difference between two results obtained on test portions of the same material tested by two different laboratories. The index, d2s, is the difference between two individual test results that would be equalled or exceeded in only one case in twenty in the normal and correct operation of the method. The index is calculated by multiplying the multi-laboratory standard deviation (1s), by the factor $2\sqrt{2}$ (2.83).

Sample mean or average is the sum of all observations divided by the total number of observations.

Median is synonymous with the middle and the **sample median** is the middle value of a list

of test results when the observations are ordered from smallest to largest in magnitude. After rearranging the observations in increasing order (from most negative to most positive), the **sample median** is the *single middle value* in the ordered list, if n is odd, or the *average of the two middle values* in the ordered list, if n is even, where n equals the number of observations.

Standard deviation is the most usual measure of the dispersion of observed values or results expressed as the positive square root of the variance.

Variance is a measure of the squared dispersion of observed values or measurements expressed as a function of the sum of the squared deviations from the population mean or sample average.

Outlier is a measurement that, for a specific degree of confidence, is not part of the population. In this study, an outlier is generally three or more standard deviations from the mean, giving a confidence level of ninety-nine percent. If a laboratory test result is classified as an outlier it means something went wrong either with the sample or in the laboratory.

Appendix B1: List of Participants for Proficiency Sample Tests

2004 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
A. L. Blair Construction Limited Moose Creek, ON Mr. B. Blanshard Tel: 613 538-2271	✓	✓				✓								✓				
Acculab Engineering and Testing Schumacher, ON Mr. H.R. Jones Tel: 705 360-5252	✓	✓				✓	✓							✓	✓			
AGS Associates Inc. Scarborough, ON Mr. A. Chohan Tel: 416 299-3655	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
AME - Materials Engineering – East Gormley, ON Mr. B. Dobson Tel: 905 640-7772	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	
AME - Materials Engineering (24-165) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-270) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-271) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-272) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-298) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-911) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-912) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME -Materials Engineering Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	

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AME -Materials Engineering - Ottawa Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME -Materials Engineering (24-297) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓				✓	✓		✓	✓			
AMEC Earth & Environmental Ltd Scarborough, ON Mr. S. Sufi Tel: 416 751-6565	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd Windsor, ON Mr. S. MacLeod Tel: 519 969-7530	✓	✓				✓								✓				
AMEC Earth & Environmental Ltd. Hamilton, ON Mr. J. Balinski Tel: 905 312-0700	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Orillia, ON Mr. Don Nicol Tel: 705 329-1542	✓	✓				✓	✓							✓	✓			
AMEC Earth & Environmental Ltd. Thorold, ON Mr. A. Markov Tel: 905 687-6616	✓	✓				✓								✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Waterloo, ON Mr. L. Maier Tel: 519 885-6220	✓	✓		✓		✓								✓	✓	✓	✓	✓
Ashwarren Engineering Services Ltd Mississauga, ON Mr. C. Graham Tel: 905 819-1290	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	
Bernt Gilbertson Enterprises Richards Landing, ON, Mr. S. Eddy Tel: 705 246-2076	✓	✓				✓								✓				
Bertrand Construction L'Original, ON Mr. P. Arnold Tel: 613 675-4614	✓	✓				✓	✓				✓	✓		✓				
Block & Associates Winnipeg, Manitoba Mr. K. Kulchyski Tel: 204 334-5356	✓	✓	✓	✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
BOT Construction Oakville, ON Mr. Sella Vicks Tel: 905 827-3250	✓	✓				✓								✓	✓			
Bruno's Contracting (Thunder Bay) Ltd. (#376), Thunder Bay, ON Mr. B. Prevost Tel: 807 623-1855	✓	✓				✓								✓				
C. Villeneuve Construction Hearst, ON Mr. C. Harris Tel: 705 372-1838	✓	✓		✓		✓	✓							✓	✓			

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C.T. Soil & Materials Engineering Inc. Windsor, ON Mr. T. J. O'Dwyer Tel: 519 966-8863	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Caledon Sand & Gravel Ltd. Caledon, ON Mr. D. Glenn Tel: 905 457-4537	✓	✓				✓								✓				
Capital Paving Inc. (Asphalt Laboratory) Guelph, ON Mr. M. Latyn Tel: 519 822-4511	✓	✓				✓	✓							✓				
Cayuga Materials & Construction Co. Ltd Cayuga, ON Mr. G. Taylor Tel: 905 772-3331	✓	✓		✓		✓	✓				✓	✓		✓	✓			
CBM Aggregates Aberfoyle Lab Cambridge, ON Mr. L. Mugford Tel: 519 824-5384	✓	✓				✓								✓				
CBM Leaside Lab Toronto, ON Mr. S. Parkes Tel: 416 423-2439	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
CBM Sunderland Lab Sunderland, ON Mr. L. Mugford Tel: 416 862-1382	✓	✓				✓	✓							✓				
Chung & Vander Dollen Engineering Limited, Kitchener, ON Mr. W. Evans Tel: 519 742-8979	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
City of Sault Ste Marie Sault Ste Marie, ON Mr. J. Sloan Tel: 705 946-9918	✓	✓				✓								✓				
Concrete Materials Lab, Dept of Engineering, U. Of Toronto Dr. R. D. Hooton Tel: 416 978-5912													✓					
Consoil Quality Control St. Catherines, ON Mr. J. Clunas Tel: 905 641-1162	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Construction Control Inc. Woodbridge, ON Mr. A. Davis Tel: 905 856-1438	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Construction Testing Asphalt Lab Oakville, ON Mr. P. Lung Tel: 905 469-6352	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Cornwall Gravel Company Limited. Cornwall, ON Mr. B. Mroz Tel: 613 932-6571	✓	✓				✓								✓				
Cox Construction Limited Guelph, ON Mr. Don Prosak Tel: 519 824-6570	✓	✓				✓	✓							✓				

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Cruickshank Construction Ltd Kingston, ON Mr. B. Green Tel: 613 542-2874	✓	✓				✓								✓				
Cruickshank Construction Ltd Morrisburg, ON Mr. D. Byvelds Tel: 613 543-2978	✓	✓				✓	✓							✓	✓			
D.F. Elliott Consulting Engineering New Liskeard, ON Mr. B. Gilbert Tel: 705 647-6871	✓	✓				✓	✓							✓	✓			
Davroc Testing Laboratories Inc. Brampton, ON Mr. S. Fasullo Tel: 905 792-7792	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DBA Engineering Limited Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
DBA Engineering Limited Mobile 10 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓	✓			
DBA Engineering Limited Mobile 5 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓	✓			
DBA Engineering Limited Mobile 7 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓	✓			
DBA Engineering Ltd. Kingston, ON Mr. M. McClelland Tel: 613 389-1781	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Dibblee Construction Limited Kingston, ON Mr. G. Bates Tel: 613 389-3232		✓				✓	✓							✓				
Dibblee Paving & Materials - Moodie Lab Nepean, ON Mr. K. Kiley Tel: 613 829-1770	✓	✓		✓		✓	✓				✓	✓		✓	✓			
District Municipality of Muskoka Bracebridge, ON Mr. D. Wood Tel: 705 645-6764	✓	✓				✓								✓	✓	✓	✓	
Drain Bros Excavating Ltd. Lakefield, ON Mr. D. Drain Tel: 705 639-2301	✓	✓				✓	✓				✓	✓		✓	✓			
DST Consulting Engineers Inc. Kenora, ON Mr. W. Foster Tel: 807 548-2383	✓	✓				✓	✓							✓	✓	✓	✓	
DST Consulting Engineers Inc. Thunder Bay, ON Ms. K. Dixon Tel: 807 623-2929	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓

2004 Participants List
Ministry of Transportation
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For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
DST Consulting Engineers Inc. Ottawa, ON Mr. C. Mahoney Tel: 613 748-1415	✓	✓				✓								✓	✓	✓	✓	
Dufferin Aggregates - Aberfoyle Lab Milton, ON Mr. J. Stewart Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Acton Lab Milton, ON Mr. J. Stewart Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates – Blair Pit Milton, ON Mr. J. Stewart Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Carden Lab Milton, ON Mr. J. Stewart Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates – Flamborough Milton, ON Mr. J. Stewart Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Millcreek Lab Milton, ON Mr. J. Stewart Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Mosport Lab Milton, ON Mr. J. Stewart Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Quality Control Lab Milton, ON Mr. J. Stewart Tel: 416 798-4772	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓	
Dufferin Construction Ltd. (QC) – Bronte Lab, Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Dufferin Construction Ltd. Mobile Lab 1 Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓			
Dufferin Construction Ltd. Mobile Lab 2 Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
E.C. King Contracting Lab #1 Owen Sound, ON Mr. H. Villneff Sr. Tel: 705 472-3312	✓	✓				✓	✓							✓				
Esko Savela & Son Contracting Inc. Thunder Bay, ON, Mr. E. Savela Tel: 807 983-2097	✓	✓				✓								✓				
Fermar Construction Limited Rexdale, ON, Mr. Mavritsakis Tel: 416 675-3550	✓	✓		✓		✓	✓							✓	✓			

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Fowler Construction Company Bracebridge, ON Mr. J. Gordon Tel: 705 645-2214	✓	✓		✓		✓	✓				✓	✓		✓	✓			
Fowler Construction Company Mobile1 Bracebridge, ON Mr. J. Gordon Tel: 705 645-2214	✓	✓		✓		✓	✓							✓	✓			
G. Tackaberry & Sons Construction Co. Ltd., Athens, ON Mr. P. Rodgers Tel: 613 924-2634	✓	✓				✓	✓							✓	✓			
Gamsby and Mannerow Limited Owen Sound, ON Mr. B. Dubeau Tel: 519 376-1805	✓	✓				✓								✓	✓			
Gazzola Paving Ltd. Etobicoke, ON Mr. S. Andualem Tel: 416 675-7007	✓	✓		✓		✓	✓							✓				
Geo-Logic Inc. Peterborough, ON Mr. W. Rayfuse Tel: 705 749-3317	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Geo-Logic Inc. Pembroke, ON Ms. E. Reid Tel: 613 735-8361	✓	✓				✓								✓	✓			
Georgian Aggregates Portable Lab Collingwood, ON Mr. Tom Risi Tel: 705 445-2300	✓	✓		✓		✓	✓			✓	✓	✓		✓				
Golder Associates Ltd. London, ON Mr. C. Sewell Tel: 519 471-9600	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Golder Associates Ltd. Mississauga, ON Ms. M. Manojlovic Tel: 905 567-4444	✓	✓				✓								✓	✓	✓	✓	✓
Golder Associates Ltd. Ottawa, ON Mrs E. Kwok Tel: 613 224-5864	✓	✓		✓	✓	✓	✓	✓						✓	✓	✓	✓	✓
Golder Associates Ltd. Sudbury, ON Ms. Tina Nantel Tel: 705 524-6861	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Whitby, ON Mr. J. Watkins Tel: 905 723-2727	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Golder Associates Ltd. Windsor, ON Mr. R. Walsh Tel: 519 945-5500	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Graham Brothers Construction Limited Brampton, ON Mr. G. Thompson Tel: 905 453-1200	✓	✓		✓		✓	✓				✓	✓		✓	✓		✓	

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Hacquoil Construction Limited Thunder Bay, ON Ms. S. Hacquoil Tel: 807 475-4096	✓	✓				✓								✓				
Halton Crushed Stone Limited Milton, ON Mr. K. Gibson Tel; 416 798-7004	✓	✓				✓	✓							✓				
Hard Rock Paving Company Limited Port Colborne, ON Ms. J. Koros Tel: 905 834-4581	✓	✓				✓	✓				✓	✓		✓	✓			
Harold Sutherland Construction Ltd. Kemble, ON Mr. R. Leigh Tel: 519 376-0603	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Huron Construction Lab No. 1 Chatham, ON Mr. D. Smith Tel: 519 354-0170	✓	✓				✓	✓							✓	✓			
Inspec-sol Inc. - Kingston Kingston, ON Mr. S. Grainger Tel: 613 389-9812	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Inspec-Sol Inc. - Mississauga Mississauga, ON Mr. K. Roechner Tel: 905 712-4771	✓	✓				✓								✓	✓	✓	✓	
Intratech Engineering Laboratories Inc. Scarborough, ON Mr. F. Miles Tel: 416 754-2077	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
J & P Leveque Bros. Ltd. Bancroft, ON Mr. W. Linnen Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓		✓	
J & P Leveque Bros. Ltd. Mobile 1 Bancroft, ON Mr. W. Linnen Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓			
Jacques Whitford Limited Ottawa, ON Mr. B. Prevost Tel: 613 738-0708	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Jacques Whitford Limited Markham. ON Mr. I. Patel Tel: 416 495-8614	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
John D. Paterson & Associates Nepean, ON Mr. C. Pelletier Tel: 613 226-7381	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
John D. Patterson & Associates North Bay, ON Mr. S. Walker Tel: 707 472-5331	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
John Emery Geotechnical Engineering Ltd, Toronto, ON Mr. D. Soanes Tel: 416 213-1060	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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John Emery Geotechnical Engineering Mobile 4, Toronto, ON Mr. D. Soanes Tel: 416 213-1060	✓	✓				✓	✓							✓	✓			
John Emery Geotechnical Engineering Mobile 6, Toronto, ON Mr. D. Soanes Tel: 416 213-1060	✓	✓				✓	✓							✓	✓			
K.J. Beamish Construction King City, ON Mr. C. Henderson Tel: 905 833-4666	✓	✓		✓		✓	✓	✓			✓	✓		✓	✓		✓	
K.J. Beamish Construction Mobile 1 King City, ON Mr. C. Henderson Tel: 905 833-4666	✓	✓				✓	✓							✓	✓			
Karson Kartage & Konstruction Stittsville, ON Mr. C. MacDonald Tel: 613 831-0717	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
Lafarge Canada Montreal, QUE, Ms. M. de Grosbois Tel: 514 738-1202													✓					
Lafarge Canada – Mosport Lab Orono, ON Mr. P. Hill Tel: 905 983-9260	✓	✓				✓	✓							✓				
Lafarge Canada – Orillia Lab Brechin, ON Ms. C. Crumbie Tel: 705 484-5225	✓	✓				✓	✓							✓				
Lafarge Canada Brechin Plant Brechin, ON Ms. C. Crumbie Tel: 705 484-5225	✓	✓		✓		✓	✓				✓	✓		✓				
Lafarge Canada Cold Water Plant Cold Water, ON Ms. W. Todd Tel: 705 484-5225	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Stouffville, ON Mr. M. Hicks Tel: 905 640-7092	✓	✓		✓		✓	✓							✓	✓			
Lafarge Canada Inc. – Byron Lab London, ON Mr. W. Harries Tel: 519 471-0520	✓	✓				✓								✓				
Lafarge Canada Inc. – Fonthill Lab Fonthill, ON Mr. J. Vingerhoets Tel: 519 853-2230	✓	✓				✓								✓				
Lafarge Canada Inc. – Hamilton Lab Hamilton, ON Mr. E. Clarkson Tel: 905 522-7735 x247	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓			✓	
Lafarge Canada Inc. – Ottawa Ottawa, ON Mr. F. Douglas Tel: 613 837-4223	✓	✓				✓	✓				✓	✓		✓				

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Lafarge Canada Limited – Caledon Lab Caledon, ON Mr. J. Kroeze Tel: 519 927-1113	✓	✓				✓	✓							✓				
Lafarge Construction Materials Ltd. – Brockville Lab, Brockville, ON Mr. P. Arkeveld Tel: 613 342-0262	✓	✓				✓	✓			✓				✓				
Lafarge Construction Materials Ltd. – Glenburnie Lab, Brockville, ON Mr. P. Arkeveld Tel: 613 342-0262	✓	✓				✓	✓							✓				
Lafarge Quarries – Dundas Lab Dundas, ON Mr. M. Whitehead Tel: 905 527-3671	✓	✓		✓		✓	✓			✓	✓	✓		✓				
Landtek Limited Hamilton, ON Mr. P. Anderson Tel: 905 383-3733	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
Lavis Contracting Co. Limited Clinton, ON Mr. A. Gardner Tel: 519 482-3694	✓	✓				✓								✓				
Law Engineering (London) Inc. London, ON Mr. J. Law Tel: 519 680-9991	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Leo Alarie and Sons Limited Timmins, ON Mr. J. Luthe Tel: 705 268-2106	✓	✓				✓	✓							✓				
M & A Associates Limited Scarborough, ON Mr. P. Balendran Tel: 416 757-8882	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
M.J. Labelle Co. Ltd. Mobile 1 Cochrane, ON Mr. P. Osmar Tel: 705 272-4201	✓	✓				✓								✓	✓			
M.J. Labelle Co. Ltd. Mobile 2 Cochrane, ON Mr. P. Osmar Tel: 705 272-4201	✓	✓				✓								✓	✓			
M.R. Wright & Associates Sault Ste. Marie, ON Mr. R. Wilson Tel: 705 945-5091	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	
Mark Smereczynsky Petrographic Services, Etobicoke, ON Mr.M.Smereczynsky Tel: 416 626-3505								✓	✓									
McAsphalt Engineering Services Toronto, ON Mr. K. Davidson Tel: 416 281-8181	✓	✓		✓		✓	✓							✓	✓			
Merlex Engineering Ltd. North Bay, ON Mr. J. P. Duhaime Tel: 705 476-2550	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓

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Mill-Am Corporation Lab #890901 Oldcastle, ON Mr. H. Villneff Sr. Tel: 519 945-7441	✓	✓				✓	✓							✓	✓			
Miller Northwestern Limited – 87526 Dryden, ON Mr. H. Villneff Sr. Tel: 807 223-2844	✓	✓		✓		✓	✓							✓	✓			
Miller Northwestern Limited – 87615, Dryden, ON Mr. H. Villneff Sr. Tel: 807 223-2844	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Ltd. - 1084 North Bay, ON Mr. H. Villneff Tel: 705 267-1107	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Ltd. - Carden Quarry Lab Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓				✓	✓							✓				
Miller Paving Ltd. - Markham Lab Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	
Miller Paving Ltd. - Whitby Lab Markham, ON Mr. N. Hanasoge Tel: 705 484-0195	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Ltd. North Bay - #8661 North Bay, ON Mr. H. Villneff Sr. Tel: 705 472-3312	✓	✓				✓	✓							✓	✓			
Miller Paving Northern - 1254 New Liskeard, ON Mr. H. Villneff Sr. Tel: 705 647-4331	✓	✓				✓	✓				✓	✓		✓	✓			
Miller Paving Northern - 60889 New Liskeard, ON Mr. H. Villneff Sr. Tel: 705 647-4331	✓	✓				✓	✓							✓	✓			
Miller Paving Northern - Mobile #60900 New Liskeard, ON Mr. H. Villneff Sr. Tel: 705 647-4331	✓	✓				✓	✓							✓	✓			
Ministry of Transportation Downsview, ON Mr. C. Rogers Tel: 416 235-3734	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mulder Construction & Materials Limited, Unit # 7004, West St. Paul, MB Mr. D. Walker Tel: 204 958-7400	✓	✓				✓								✓				
Mulder Construction & Materials Limited, Unit # 7005, West St. Paul, MB Mr. D. Walker Tel: 204 958-7400	✓	✓				✓												
National Testing Laboratories Ltd. Winnipeg, Manitoba Mr. D. Flatt Tel: 204 488-6999	✓	✓	✓	✓	✓	✓								✓	✓			

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Naylor Engineering Associates Ltd Kitchener, ON Ms. A. Snyder Tel: 519 741-1313	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Nelson Aggregate Co. Beamsville, ON Mr. T. Scambato Tel: 905 563-8226	✓	✓				✓	✓							✓				
Nelson Aggregate Co. Burlington, ON Mr. M. Rook Tel: 905 336-0453	✓	✓				✓	✓							✓				
Pedersen Construction Inc. New Liskeard, ON Mr. W. Campsall Tel: 705 647-6223	✓	✓				✓								✓				
Peto MacCallum Ltd. Barrie, ON Mr. T. Lee-Bun Tel: 705 734-3900	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Peto MacCallum Ltd. Brampton, ON Mr. R. Midgley Tel: 905 796-3650	✓	✓		✓		✓	✓							✓	✓			
Peto MacCallum Ltd. Hamilton, ON Mr. E.L. Truax Tel: 905 561-2231	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Peto MacCallum Ltd. Kitchener, ON Mr. T. Smith Tel: 519 893-7500	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Peto MacCallum Ltd. Toronto, ON Mr. A. Nathoo Tel: 416 785-5110	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Peto MacCallum Ltd. Mobile 1 Brampton, ON Mr. R. Midgley Tel: 905 796-3650	✓	✓				✓								✓	✓			
Pioneer Construction Inc. - Garson Sault Ste. Marie, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓				✓								✓	✓			
Pioneer Construction Inc. – Kenora C-1 Kenora, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. – Main Lab Sault Ste. Marie, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Pioneer Construction Inc. – Mobile C-2 Sault Ste. Marie, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. – Thunder Bay Sault Ste. Marie, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓				✓	✓							✓	✓			

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	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Pioneer Construction Inc. - Main Lab Sudbury, ON Mr. K. Edwards Tel: 705 560-7200	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓	✓
Pioneer Construction Inc. - Mobile 1 Sudbury, ON Mr. K. Edwards Tel: 705 560-7200	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. - Mobile 2 Sudbury, ON Mr. K. Edwards Tel: 705 560-7200	✓	✓				✓	✓							✓	✓			
Precision Age Aggregate Testing Ltd. Thunder Bay, ON Mr. W. Werbowetski Tel: 807 577-3927								✓	✓									
Preston Sand & Gravel Kitchener, ON Mr. M. Bell Tel: 519 579-1248	✓	✓				✓	✓							✓				
Regional Municipality of Durham, Materials Testing Division, Whitby, ON Mr. C. Morley Tel: 905 655-3344	✓	✓		✓		✓	✓							✓	✓			
R. W. Tomlinson Limited Gloucester, ON Mr. B. Hendriks Tel: 613 822-1867	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓		✓	✓
Royel Paving Limited Mobile 1 Lindsay, ON Mr. J. Simmons Tel: 705 324-6773	✓	✓				✓	✓							✓	✓			
Sarafinchin Associates Ltd. Rexdale, ON Mr. S. Jeffrey Tel: 416 674-1770	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Shaba Testing Services Limited Chaput Hughes, ON Mr. L. Shaba Tel: 705 567-4187	✓	✓				✓								✓	✓			
Shaheen & Peaker Limited Toronto, ON Mr. A. Mendonca Tel: 416 213-1255	✓	✓				✓	✓							✓	✓	✓	✓	✓
Shaheen & Peaker Limited (Geo-Canada) Markham, ON Mr. S. Peaker Tel: 905 474-9255	✓	✓				✓	✓							✓	✓	✓	✓	✓
Shaheen Peaker Thompson Limited Oshawa ON Mr. D. Thompson Tel: 905 436-9028	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
Site Investigation Services, Division of Jagger Hims Ltd, Peterborough, ON Mr. S. Ash Tel: 705 743-6850	✓	✓				✓								✓				
Smelter Bay Aggregates Inc. Thessalon, ON Mr. C. Hemden Tel: 705 842-3908	✓	✓				✓	✓							✓				

2004 Participants List
Ministry of Transportation
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Chris Rogers (416) 235-3734

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Smith's Construction Co. Amprior Ltd - 8660, Amprior, ON Mr. H. Villneff Tel: 613 623-3144	✓	✓				✓	✓							✓				
Smith's Construction Co. Amprior Ltd - 60-853, Amprior, ON Mr. H. Villneff Tel: 613 623-3144	✓	✓				✓	✓							✓				
Soil-Eng Limited Scarborough, ON Mr. S. Sanjeevan Tel: 416 754-8515	✓	✓				✓	✓							✓	✓	✓	✓	✓
Soil-Mat Limited Hamilton, ON Mr. J. Monkman Tel: 905 318-7400	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
St Lawrence Testing & Inspection Co. Ltd Cornwall, ON Mr. G. McIntee Tel: 613 938-2521	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Steed and Evans Limited Heidelberg, ON Mr. R. Marco Tel: 519 699-4646	✓	✓				✓	✓							✓				
Strada Aggregates Concord, ON Ms. J. Lockyer Tel: 905 738-2200	✓	✓				✓								✓				
Sutcliffe Rody Quesnel Limited New Liskeard, ON Mr. P. Seguin Tel: 705 647-4311	✓	✓				✓	✓								✓			
Sutton and Associates Smithville, ON Mr. K. MacDonald Tel: 905 957-6893	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Teranorth Construction & Engineering Limited, Sudbury, ON Mr. James Bot Tel: 705 523-1540	✓	✓				✓	✓							✓	✓			
Terraprobe Limited Brampton, ON Mr. K. Buth Tel: 905 796-2650	✓	✓		✓		✓	✓	✓						✓	✓	✓	✓	✓
Terraprobe Limited Barrie, ON Mr. B. Jackson Tel: 705 739-8355	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Terraprobe Limited (Mountainview) Stoney Creek, ON Mr. G. Muckle Tel: 905 643-7560	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Terraprobe Limited Sudbury Sudbury, ON Mr. R. Carniello Tel: 705 670-0460	✓	✓				✓								✓	✓	✓	✓	
Terraspec Engineering Peterborough, ON Mr. S. Galloway Tel: 705 743-7880	✓	✓				✓								✓	✓	✓	✓	✓

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The Murray Group Moorefield, ON Mr. B. Mitchel Tel: 519 638-3077	✓	✓				✓	✓							✓				
Thomas Cavanagh Construction Ltd. Ashton, ON Mr. P. White Tel: 613 259-2670	✓	✓				✓								✓				
Thunder Bay Testing and Engineering Thunder Bay, ON Mr. T. Fummerton Tel: 807 623-5278	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Thurber Engineering Limited Oakville, ON Dr. P. K. Chatterji Tel: 905 829-8666	✓	✓				✓								✓	✓	✓	✓	✓
Towland (London) 1970 Limited London, ON Mr. Shawn Dietze Tel: 519 451-2750	✓	✓		✓		✓	✓							✓	✓			
Trow Consulting Engineers Limited Brampton, ON Mr. S. Lee Tel: 905 793-9800	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trow Consulting Engineers Limited London, ON Ms. R. Walker Tel: 519 453-1480	✓	✓				✓	✓							✓	✓			
Trow Consulting Engineers Limited Stoney Creek, ON Mr. C. Douglas Tel: 905 664-3300	✓	✓		✓		✓	✓							✓	✓			
Trow Consulting Engineers Limited Sudbury, ON Mr. R. Ferguson Tel: 705 674-9681	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Trow Consulting Engineers Ltd. Nepean, ON Mr. I.M. Taki Tel: 613 225-9940	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Trow Consulting Engineers Ltd. Thunder Bay, ON Mr. K. Mosley Tel: 807 623-9495	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	
Trow Consulting Engineers Ltd. Barrie, ON Mr. L. Knegt Tel: 705 734-6222	✓	✓				✓	✓							✓	✓			
Vicdom Sand and Gravel Ltd. Uxbridge, ON Mr. B. Giordano Tel: 905 649-2193	✓	✓				✓	✓							✓				
Walker Brothers Quarries Limited Thorold, ON Mr. Tom Risi Tel: 905 680-3750	✓	✓		✓		✓	✓				✓	✓		✓				
Warren Bitulithic Toronto, ON Mr. A. Pahalan Tel: 416 633-9670	✓	✓		✓		✓	✓							✓				

2004 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Warren Bitulithic Ltd Kitchener, ON Mr. A. Smith Tel: 519 696-2274	✓	✓		✓		✓	✓							✓				
Warren Paving Ltd. Cobourg, ON Mr. G. Bates Tel: 905 372-4671	✓	✓		✓		✓	✓				✓	✓		✓	✓		✓	

Appendix B2: List of Participants for Consensus Property Tests

2004 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program Contact Chris Rogers at (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4719 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
AME -Materials Engineering Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓	✓	✓
AMEC Earth & Environmental Limited Hamilton, ON Mr. J. Balinski Tel: 905 312-0700	✓	✓	✓	✓
Ashwarren Engineering Services Limited Mississauga, ON Mr. C. Graham Tel: 905 819-1290	✓	✓	✓	✓
Construction Testing Asphalt Lab Oakville, ON Mr. P. Lung Tel: 905 469-6352	✓	✓	✓	✓
DBA Engineering Limited Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓	✓	✓
DST Consulting Engineers Inc. Thunder Bay, ON Ms. K. Dixon Tel: 807 623-2929	✓	✓	✓	✓
Dufferin Aggregates Quality Control Milton, ON Mr. J. Stewart Tel: 416 798-4772	✓	✓	✓	✓
Dufferin Construction Ltd. (QC) – Bronte Lab Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓	✓	✓
Dufferin Construction Ltd. Mobile Lab No. 1 Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓	✓	✓
Fowler Construction Company Bracebridge, ON Mr. J. Gordon Tel: 705 645-2214	✓	✓	✓	✓
Fowler Construction Company Mobile 1 Bracebridge, ON Mr. J. Gordon Tel: 705 645-2214	✓	✓	✓	✓
Geo-Logic Inc. Peterborough, ON Mr. W. Rayfuse Tel: 705 749-3317	✓	✓	✓	✓
Golder Associates Ltd. London, ON Mr. C. Sewell Tel: 519 471-9600	✓	✓	✓	✓
Golder Associates Ltd. Sudbury, ON Ms. Tina Nantel Tel: 705 524-6861	✓	✓	✓	✓
Golder Associates Ltd. Whitby, ON Mr. J. Watkins Tel: 905 723-2727	✓	✓	✓	✓
Graham Bros. Construction Limited Brampton, ON Mr. G. Thompson Tel: 905 453-1200	✓	✓	✓	✓
Hard Rock Paving Company Limited Port Colborne, ON Ms. J. Koros Tel: 905 834-4581			✓	✓

2004 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program Contact Chris Rogers at (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4719 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
Jacques Whitford Limited Ottawa, ON Mr. B. Prevost Tel 613 738-0708	✓	✓	✓	✓
John D. Patterson & Associates North Bay, ON Mr. S. Walker Tel 707 472-5331	✓	✓	✓	✓
John Emery Geotechnical Engineering Limited Etobicoke, ON Mr. D. Soares Tel 416 213-1060	✓	✓	✓	✓
K.J. Beamish Construction King City, ON Mr. C. Henderson Tel 905 833-4666	✓	✓	✓	✓
Karson Kartage & Konstruction Stittsville, ON Mr. C. MacDonald Tel 613 831-0717	✓	✓	✓	✓
Lafarge Canada Inc. – Hamilton Lab Hamilton, ON Mr. E. Clarkson Tel 905 522-7735	✓		✓	✓
McAsphalt Engineering Services Toronto, ON Mr. K. Davidson Tel 416 282-8181	✓	✓	✓	✓
Mill-Am Corporation – Lab No. 890901 Oldcastle, ON Mr. H. Villlneff Sr Tel 519 945-7441	✓	✓	✓	✓
Miller Northwestern Limited - 87526 Dryden, ON Mr. H. Villlneff Sr Tel 807 223-2844	✓	✓	✓	✓
Miller Paving Ltd – Mobile Lab #1084 North Bay, ON Mr. H. Villneff Sr Tel 705 267-1107	✓	✓	✓	✓
Miller Paving Ltd. - Markham Lab Markham, ON Mr. N. Hanasoge Tel 905 475-6660	✓	✓	✓	✓
Ministry of Transportation Downsview, ON Mr. C. Rogers Tel 416 235-3734	✓	✓	✓	✓
Peto MacCallum Ltd. Hamilton, ON Mr. E.L. Truax Tel: 905 561-2231	✓	✓	✓	✓
Peto MacCallum Ltd. Kitchener, ON Mr. T. Smith Tel: 519 893-7500	✓	✓	✓	✓
Peto MacCallum Ltd. Toronto, ON Mr. A. Nathoo Tel: 416 785-5110	✓	✓	✓	✓
Pioneer Construction Inc. Sault Ste. Marie, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓	✓	✓
Pioneer Construction Inc. (Main Lab) Sudbury, ON Mr. K. Edwards Tel: 705 560-7200	✓	✓	✓	✓
R. W. Tomlinson Limited Gloucester, ON Mr. B. Hendriks Tel: 613 822-6884	✓	✓	✓	✓
St Lawrence Testing & Inspection Co. Ltd Cornwall, ON Mr. G. McIntee Tel: 613 938-2521	✓	✓	✓	✓
Terraprobe Limited Brampton, ON Mr. K. Buth Tel: 905 796-2650	✓	✓	✓	✓
Thunder Bay Testing and Engineering Thunder Bay, ON Mr. T. Fummerton Tel: 807 623-5278	✓	✓	✓	✓

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Trow Consulting Engineers Limited Brampton, ON Mr. S. Lee Tel: 905 793-9800	✓	✓	✓	✓
Trow Consulting Engineers Limited Nepean, ON Mr. I. M. Taki Tel: 613 225-9940	✓	✓	✓	✓
Trow Consulting Engineers Limited Sudbury, ON Mr. R. Ferguson Tel: 705 674-9681	✓	✓	✓	✓
Walker Brothers Quarries Thorold, ON Mr. Tom Risi Tel: 905 680-3750	✓		✓	✓

Appendix C: Multi-Laboratory Precision Tables

Test 1	2001		2002		2003		2004		ASTM C117
WP 75 µm	1.01	2 01	1 02	2.02	1.03	2.03	1.04	2.04	
Mean	0.85	0 90	0 89	0.86	1.09	1.22	1.01	1.03	<1.5
1S	0.13	0 12	0 22	0.19	0.30	0.28	0.15	0.13	0.22
D2S	0.36	0 34	0 62	0.54	0.85	0.80	0.43	0.37	0.62
n/Outliers	169/35		192/16		197/6		197/6		

Test 8	2001		2002		2003		2004		ASTM C131	
L. L. A	1.01	2 01	1 02	2.02	1.03	2.03	1.04	2.04	C of V	σ*
Mean	24.68	24 92	24 20	24.27	23.70	24.36	21.54	21.27	10-45	24.2
1S	1.54	1 26	1 68	0.87	2.07	1.39	0.91	1.45	4.5%	1.09
D2S	4.36	3 58	4 75	2.45	5.87	3.94	2.57	4.09	12.7%	3.08
n/Outliers	11/1		11/2		11/1		9/2			

Test 9	2001		2002		2003		2004		ASTM C127 - 01
RD (O.D)	1.01	2 01	1 02	2.02	1.03	2.03	1.04	2.04	
Mean	2.686	2 684	2 671	2.670	2.669	2.668	2.687	2.686	
1S	0.008	0 007	0 008	0.007	0.007	0.007	0.006	0.006	0.013
D2S	0.022	0 020	0 023	0.020	0.020	0.020	0.017	0.017	0.038
n/Outliers	79/10		81/9		86/3		89/6		

Test 10	2001		2002		2003		2004		ASTM C127 - 88
ABS	1.01	2 01	1 02	2.02	1.03	2.03	1.04	2.04	
Mean	1.645	1 662	0 675	0.666	0.697	0.710	0.463	0.470	< 2%
1S	0.089	0 076	0 076	0.079	0.079	0.078	0.064	0.073	0.145
D2S	0.252	0 215	0 215	0.223	0.223	0.221	0.181	0.206	0.41
n/Outliers	82/7		86/4		87/2		91/4		

Test 11	2001		2002		2003		2004		ASTM C88	
MgSO4	1.01	2 01	1 02	2.02	1.03	2.03	1.04	2.04	C of V	σ*
Mean	5.0	5 1	12 5	12.8	13.8	13.8	5.4	5.2	9-20%	13.8
1S	1.9	1 9	3 0	3.2	3.4	3.0	2.0	1.7	25%	3.45
D2S	5.4	5 4	8 5	9.0	9.7	8.5	5.7	4.7	71%	9.7
n/Outliers	40/1		35/0		34/1		34/1			

Test 12	2001		2002		2003		2004		MTO Workshop
% Crush	1.01	2 01	1 02	2.02	1.03	2.03	1.04	2.04	
Mean	60.0	59 7	70 0	70.2	64.3	64.7	69.2	69.7	50 - 75
1S	4.6	4 9	5 3	5.6	5.4	5.8	4.7	4.9	6.0%
D2S	13.0	13 9	15 0	15.8	15.4	16.5	13.5	13.9	16.9%
n/Outliers	177/26		186/22		197/5		188/15		

Test 13	2001		2002		2003		2004		ASTM D 4791
% F & E	1.01	2.01	1 02	2.02	1.03	2.03	1.04	2.04	
Mean	3.3	3.5	3.4	3.1	3.8	3.6	9.2	8.9	No ASTM
1S	2.0	2.0	1.8	1.6	2.6	2.2	3.7	3.5	Precision
D2S	5.7	5.7	5.1	4.5	7.3	6.2	10.5	9.9	Statements for
n/Outliers	142/13		145/19		158/4		160/7		this test

A – AMRL reports percent passing inch series equivalent sieves.

σ* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 14	2001		2002		2003		2004		ASTM
PN Conc.	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	110.7	110.3	Analysis		Analysis		150.9	145.3	No ASTM
1S	7.5	5.9	Not		Not		6.9	12.3	Standard for this
D2S	21.4	16.7	Done		Done		19.6	34.9	Test.
n/Outliers	30/2						20/6		

Test 16	2001		2002		2003		2004		MTO LS - 618
MDA, CA	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	6.60	6.53	19.16	18.97	19.18	19.07	10.53	10.53	12
1S	0.49	0.47	0.95	0.93	1.01	0.95	0.53	0.53	0.77
D2S	1.40	1.35	2.69	2.63	2.85	2.68	1.51	1.51	2.17
n/Outliers	60/5		62/4		62/1		58/4		

Test 17	2001		2002		2003		2004		MTO LS - 614
Freeze-thaw	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	5.65	5.84	15.64	15.44	15.93	16.06	17.48	17.65	19
1S	1.53	1.47	4.41	3.93	3.44	2.95	3.72	3.77	1.7
D2S	4.33	4.17	12.48	11.13	9.73	8.36	10.53	10.68	4.9
n/Outliers	49/3		50/2		45/3		47/1		

Test 2	2001		2002		2003		2004		ASTM C136[A]
P 19.0 mm	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	94.1	94.1	98.4	98.4	99.0	99.0	97.7	97.6	100 - 95
1S	1.1	1.0	0.5	0.5	0.3	0.3	0.5	0.6	0.35
D2S	3.1	2.8	1.4	1.4	0.9	0.9	1.5	1.8	1.0
n/Outliers	207/1		208/3		198/6		203/1		

Test 3	2001		2002		2003		2004		ASTM C136[A]
P 16.0 mm	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	86.2	86.4	92.7	92.8	94.6	94.5	89.5	89.0	95 - 85
1S	1.3	1.2	0.9	0.9	0.8	0.7	1.3	1.4	1.37
D2S	3.7	3.4	2.7	2.5	2.2	2.2	3.6	3.9	3.9
n/Outliers	204/4		205/6		202/2		203/1		

Test 4	2001		2002		2003		2004		ASTM C136[A]
P 13.2 mm	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	79.1	79.4	86.5	86.6	88.0	87.8	79.8	78.9	80 – 60
1S	1.5	1.3	1.4	1.1	1.1	1.1	1.8	2.1	2.82
D2S	4.3	3.8	3.9	3.1	3.2	3.2	5.2	5.9	8.0
n/Outliers	201/7		204/7		201/3		203/1		

Test 5	2001		2002		2003		2004		ASTM C136[A]
P 9.5 mm	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	67.3	67.4	72.6	71.5	74.9	74.8	64.8	63.6	80 – 60
1S	1.5	1.3	1.9	1.6	1.2	1.3	2.0	2.5	2.82
D2S	4.2	3.9	5.4	4.4	3.4	3.7	5.6	7.1	8.0
n/Outliers	200/8		200/11		200/4		201/3		

Test 6	2001		2002		2003		2004		ASTM C136[A]
P 4.75 mm	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	51.1	51.1	48.5	44.7	55.7	56.1	47.5	46.6	60 – 20
1S	1.4	1.4	2.7	2.2	1.4	1.5	1.9	2.4	1.97
D2S	4.0	3.9	7.8	6.4	4.0	4.3	5.5	6.7	5.6
n/Outliers	197/11		205/6		198/5		203/1		

A – AMRL reports percent passing inch series equivalent sieves.

σ^{*} - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 20	2001		2002		2003		2004		ASTM C136[A]
P 2.36 mm	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	41.8	41.9	40.1	36.6	42.4	43.1	37.2	36.4	60 – 20
1S	1.5	1.6	2.8	2.5	1.9	2.1	1.9	2.1	1.41
D2S	4.3	4.5	8.0	7.2	5.3	5.8	5.6	5.8	4.0
n/Outliers	194/14		205/6		202/2		202/2		

Test 21	2001		2002		2003		2004		ASTM C136[A]
P 1.18 mm	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	34.1	34.3	32.9	29.8	30.8	32.1	28.4	27.9	60 – 20
1S	1.7	1.8	2.7	2.3	2.1	2.0	1.9	2.0	1.41
D2S	4.9	5.2	7.6	6.6	5.9	5.7	5.3	5.6	4.0
n/Outliers	198/10		205/6		202/2		202/2		

Test 22	2001		2002		2003		2004		ASTM C136[A]
P 600 µm	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	25.4	25.6	24.2	21.9	22.7	24.2	19.7	19.4	20 – 15
1S	1.6	1.6	2.3	1.9	1.8	1.7	1.5	1.7	1. 01
D2S	4.6	4.6	6.5	5.4	5.0	4.9	4.3	4.9	3.10
n/Outliers	197/11		203/8		202/2		203/1		

Test 23	2001		2002		2003		2004		ASTM C136[A]
P 300 µm	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	14.0	14.2	13.6	12.4	17.1	18.2	12.2	12.0	15 – 10
1S	0.9	0.9	1.4	1.3	1.3	1.2	1.1	1.2	0.73
D2S	2.7	2.7	4.0	3.7	3.8	3.5	3.0	3.5	2.10
n/Outliers	191/17		202/9		201/3		204/0		

Test 24	2001		2002		2003		2004		ASTM C136[A]
P 150 µm	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	7.7	7.8	4.9	4.5	12.6	13.3	8.3	8.1	10 – 2
1S	0.5	0.5	0.6	0.6	0.9	0.8	0.7	0.9	0.65
D2S	1.3	1.5	1.6	1.7	2.6	2.3	2.1	2.6	1.8
n/Outliers	189/19		201/10		200/4		203/1		

Test 25	2001		2002		2003		2004		ASTM C136[A]
P 75 µm	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	5.3	5.4	1.8	1.8	9.2	9.6	6.3	6.1	10 – 2
1S	0.4	0.4	0.2	0.3	0.6	0.6	0.6	0.7	0.65
D2S	1.1	1.1	0.7	0.8	1.7	1.7	1.7	2.1	1.8
n/Outliers	193/15		204/7		200/4		202/2		

Test 27	2001		2002		2003		2004		ASTM C 128
RD (O.D)	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	2.654	2.652	2.718	2.717	2.654	2.656	2.602	2.600	
1S	0.013	0.015	0.015	0.013	0.012	0.012	0.015	0.019	0.023
D2S	0.036	0.042	0.042	0.037	0.034	0.034	0.042	0.054	0.066
n/Outliers	78/7		77/9		77/10		82/11		

Test 28	2001		2002		2003		2004		ASTM C 128
ABS	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	0.76	0.78	0.95	0.97	0.85	0.82	1.717	1.719	< 1.0%
1S	0.16	0.19	0.18	0.19	0.20	0.15	0.19	0.30	0.23
D2S	0.47	0.53	0.52	0.54	0.58	0.43	0.56	0.85	0.66
n/Outliers	78/7		81/5		78/9		83/10		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 29	2001		2002		2003		2004		ASTM C88
MgSO4	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	8.3	8.3	7.4	7.3	14.4	14.1	11.9	11.9	ASTM precision
1S	3.5	3.3	3.2	2.8	4.4	4.6	4.5	4.5	statements for
D2S	9.8	9.3	9.2	8.0	12.6	13.0	12.9	12.9	coarse
n/Outliers	33/2		31/0		32/0		33/0		aggregate only

Test 30	2001		2002		2003		2004		MTO LS-621
% ACP	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	29.8	29.7	28.1	41.8	39.3	38.9	41.3	40.6	No MTO
1S	2. 8	2.9	2.7	5.4	5.2	4.7	4.9	4.4	precision
D2S	8.1	8.3	7.6	15.2	14.7	13.3	14.0	12.6	statements for
n/Outliers	190/12		202/7		195/5		196/6		this test

Test 31	2001		2002		2003		2004		MTO LS-623
MWD	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	2.248	2.249	2.146	2.153	2.409	2.407	2.280	2.281	No MTO
1S	0.028	0.026	0.028	0.030	0.044	0.051	0.029	0.041	precision
D2S	0.079	0.073	0.079	0.085	0.124	0.144	0.082	0.116	statements for
n/Outliers	127/17		130/14		134/4		133/8		this test

Test 32	2001		2002		2003		2004		MTO LS-623
MDD	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	2.066	2.066	1.941	1.949	2.252	2.251	2.102	2.105	No MTO
1S	0.028	0.029	0.032	0.032	0.049	0.052	0.033	0.040	precision
D2S	0.079	0.082	0.090	0.090	0.138	0.147	0.093	0.113	statements for
n/Outliers	129/15		133/11		134/4		136/5		this test

Test 33	2001		2002		2003		2004		MTO LS-623
OMC	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	8.89	8.88	10.63	10.53	7.13	7.15	8.47	8.48	No MTO
1S	0.51	0.55	0.52	0.54	0.44	0.45	0.45	0.49	precision
D2S	1.43	1.57	1.47	1.53	1.25	1.28	1.28	1.39	statements for
n/Outliers	133/10		136/8		136/2		141/0		this test

Test 34	2001		2002		2003		2004		MTO LS-619
MDA, FA3	3.01	4.01	3.02	4.02	3.03	4.03	3.04	4.04	
Mean	11.1	11.1	13.7	13.8	15.1	15.1	16.6	16.7	19.0
1S	0.9	0.9	1.3	1.2	1.1	1.1	1.5	1.4	1.06
D2S	2.7	2.6	3.7	3.4	3.2	3.0	4.1	4.1	3.0
n/Outliers	62/2		61/2		61/3		61/1		

Test 40	2001		2002		2003		2004		MTO LS-702
P 2.0 mm	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	99.9	99.9	100.0	99.9	100.0	100.0	100.0	100.0	No MTO
1S	0.08	0.06		0.05					precision
D2S	0.25	0.17		0.13					statements for
n/Outliers	69/18		60/16		57/8		67/0		this test

Test 41	2001		2002		2003		2004		MTO LS-702
P 425 µm	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	96.3	96.3	98.3	96.3	98.3	98.3	97.1	97.0	No MTO
1S	0.3	0.5	0.5	0.5	0.5	0.4	0.6	0.6	precision
D2S	0.9	1.5	1.4	1.3	1.4	1.1	1.7	1.7	statements for
n/Outliers	65/22		60/15		61/4		60/7		this test

A – AMRL reports percent passing inch series equivalent sieves.

σ^{*} - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 42	2001		2002		2003		2004		MTO LS-702
P 75 µm	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	88.6	88.7	92.5	88.6	92.5	92.5	91.7	91.7	No MTO
1S	0.5	0.5	0.7	0.4	0.9	0.8	0.9	0.8	precision
D2S	1.4	1.4	2.1	1.1	2.5	2.2	2.7	2.4	statements for
n/Outliers	62/25		58/17		59/6		59/8		this test

Test 43	2001		2002		2003		2004		MTO LS-702
P 20 µm	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	69.6	69.8	63.5	70.2	63.5	62.3	78.1	78.5	No MTO
1S	4.0	3.8	3.8	4.0	5.4	4.3	3.3	3.8	precision
D2S	11.4	10.7	10.7	11.5	15.3	12.3	9.5	10.8	statements for
n/Outliers	68/19		66/9		61/4		60/7		this test

Test 44	2001		2002		2003		2004		MTO LS-702
P 5 µm	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	43.8	44.0	45.0	44.7	45.8	45.1	59.0	58.8	No MTO
1S	3.2	2.9	3.5	3.0	4.1	4.1	4.3	3.8	precision
D2S	9.1	8.2	10.0	8.6	11.7	11.6	12.1	10.7	statements for
n/Outliers	66/21		66/9		62/3		62/5		this test

Test 45	2001		2002		2003		2004		MTO LS-702
P 2 µm	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	30.9	30.9	33.4	31.1	35.4	34.7	44.4	44.6	No MTO
1S	2.7	2.9	3.7	3.4	4.5	4.3	2.8	2.7	precision
D2S	7.6	8.2	10.6	9.5	12.9	12.1	7.9	7.7	statements for
n/Outliers	66/21		67/8		63/2		57/10		this test

Test 46	2001		2002		2003		2004		ASTM D 4318
L. L	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	27.3	27.3	34.1	27.4	34.0	33.8	36.9	37.2	33.3
1S	1.18	1.18	2.8	1.6	2.2	1.9	1.8	1.7	0.8
D2S	3.34	3.36	7.92	4.47	6.3	5.5	5.0	4.9	2
n/Outliers	74/7		73/5		77/1		75/2		

Test 47	2001		2002		2003		2004		ASTM D 4318
P. L	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	15.3	15.4	17.8	15.5	17.6	17.6	19.3	19.2	19.9
1S	1.01	0.98	1.65	1.24	1.92	1.78	1.4	1.4	1.3
D2S	2.86	2.78	4.68	3.52	5.4	5.0	3.9	4.0	4
n/Outliers	76/5		72/6		77/1		74/3		

Test 48	2001		2002		2003		2004		ASTM D 4318
P. I	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	12.2	12.1	16.2	11.9	16.1	16.0	17.5	18.0	13.4
1S	1.69	1.74	2.93	1.42	2.71	2.67	2.1	2.3	1.6
D2S	4.79	4.92	8.30	4.01	7.66	7.56	6.1	6.4	4
n/Outliers	79/2		73/5		78/0		76/1		

Test 49	2001		2002		2003		2004		AASHTO T 100
SG of Soils	5.01	6.01	5.02	6.02	5.03	6.03	5.04	6.04	
Mean	2.720	2.725	2.713	2.732	2.703	2.699	2.729	2.733	
1S	0.026	0.025	0.035	0.026	0.041	0.042	0.029	0.029	0.04
D2S	0.073	0.071	0.099	0.073	0.116	0.118	0.082	0.082	0.11
n/Outliers	55/8		56/9		58/0		50/10		

A – AMRL reports percent passing inch series equivalent sieves.

σ^{*} - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 95	2002		2003		2004		2005		ASTM C 1252
UC Void	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	42.81	42.72	41.64	42.12	42.09	41.81			ASTM C 1252[A]
1S	0.84	0.64	1.62	1.35	1.48	1.11			0.33%
D2S	2.38	1.81	4.58	3.83	4.19	3.15			0.93%
n/Outliers	18/2		28/4		35/6				

Test 96	2002		2003		2004		2005		ASTM D 2419
SE Value	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	90.11	89.52	31.15	31.19	49.9	50.6			< 80
1S	2.62	2.02	3.51	2.80	8.08	8.60			8.0
D2S	7.41	5.72	9.93	7.92	22.88	24.30			22.6
n/Outliers	18/0		28/1		38/0				

Test 97	2002		2003		2004		2005		ASTM D 5821
% Fractured	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	71.34	72.39	66.12	67.07	71.18	71.51			76.0%
1S	4.19	4.95	6.78	6.65	5.02	5.01			5.2%
D2S	11.86	14.01	19.19	18.82	14.20	14.18			14.7%
n/Outliers	20/0		32/1		42/0				

Test 99	2002		2003		2004		2005		AST D 4719
% F & E	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	0.59	0.48	0.46	0.38	1.75	1.61			No ASTM
1S	0.62	0.53	0.52	0.42	1.12	0.93			precision
D2S	1.75	1.50	1.47	1.19	3.13	2.64			statements for
n/Outliers	19/1		32/2		40/2				this test

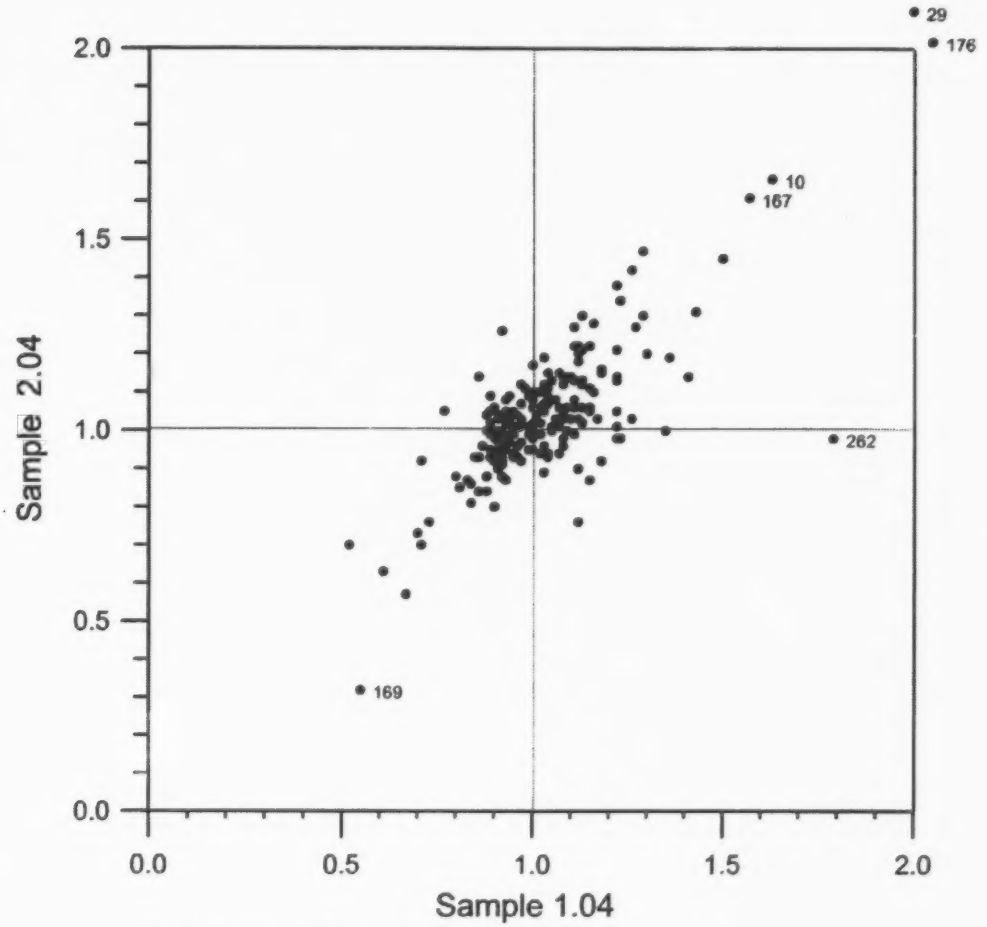
Test 123	2004		2005		2006		2007		ASTM C 1260
Mortar Bar	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean	0.196	0.410							Expansion>0.1%
1S	0.035	0.051							15.2%
D2S	0.099	0.144							43 %
n/Outliers	16/0								

A – AMRL reports percent passing inch series equivalent sieves.

$\hat{\sigma}$ - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Appendix D1: Scatter Diagrams for Proficiency Sample Tests

2004 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

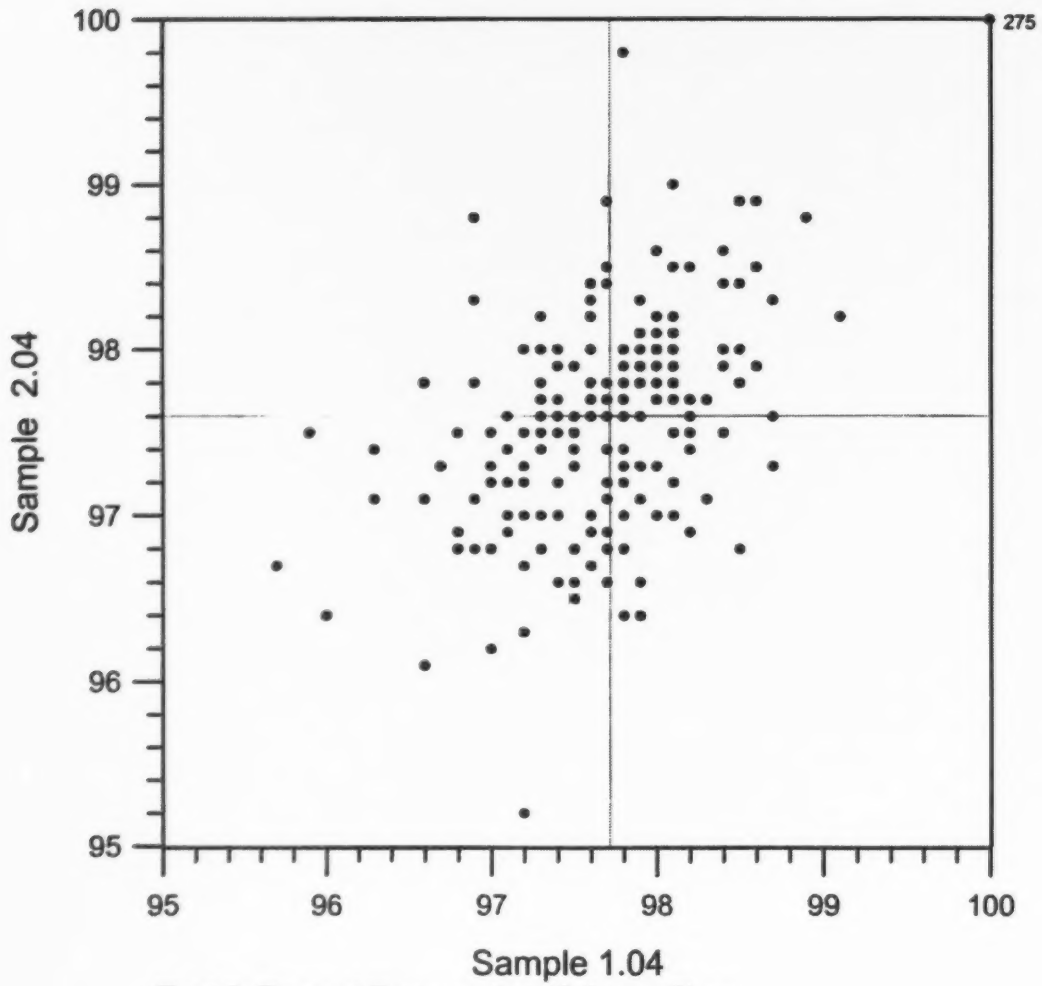


Test 1: Wash Pass 75 um

	Mat 1	Mat 2
Mean	1.013	1.028
Median	1.010	1.020
Std Dev	0.152	0.132
n = 197		

Labs Eliminated: 10, 29, 167, 169, 176, 262

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

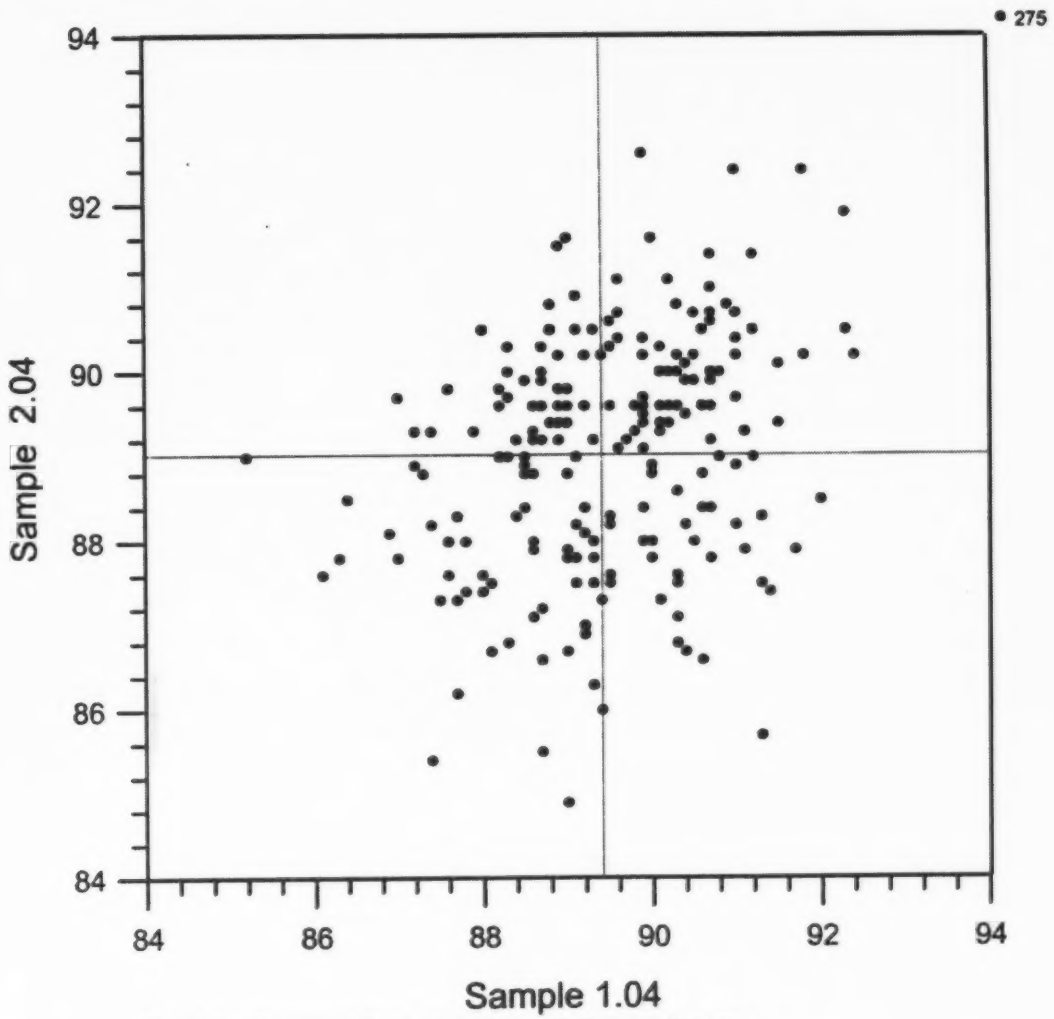


Test 2: Percent Passing the 19.0 mm Sieve

	Mat 1	Mat 2
Mean	97.664	97.600
Median	97.400	97.500
Std Dev	0.544	0.646
n = 203		

Lab Eliminated: 275

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

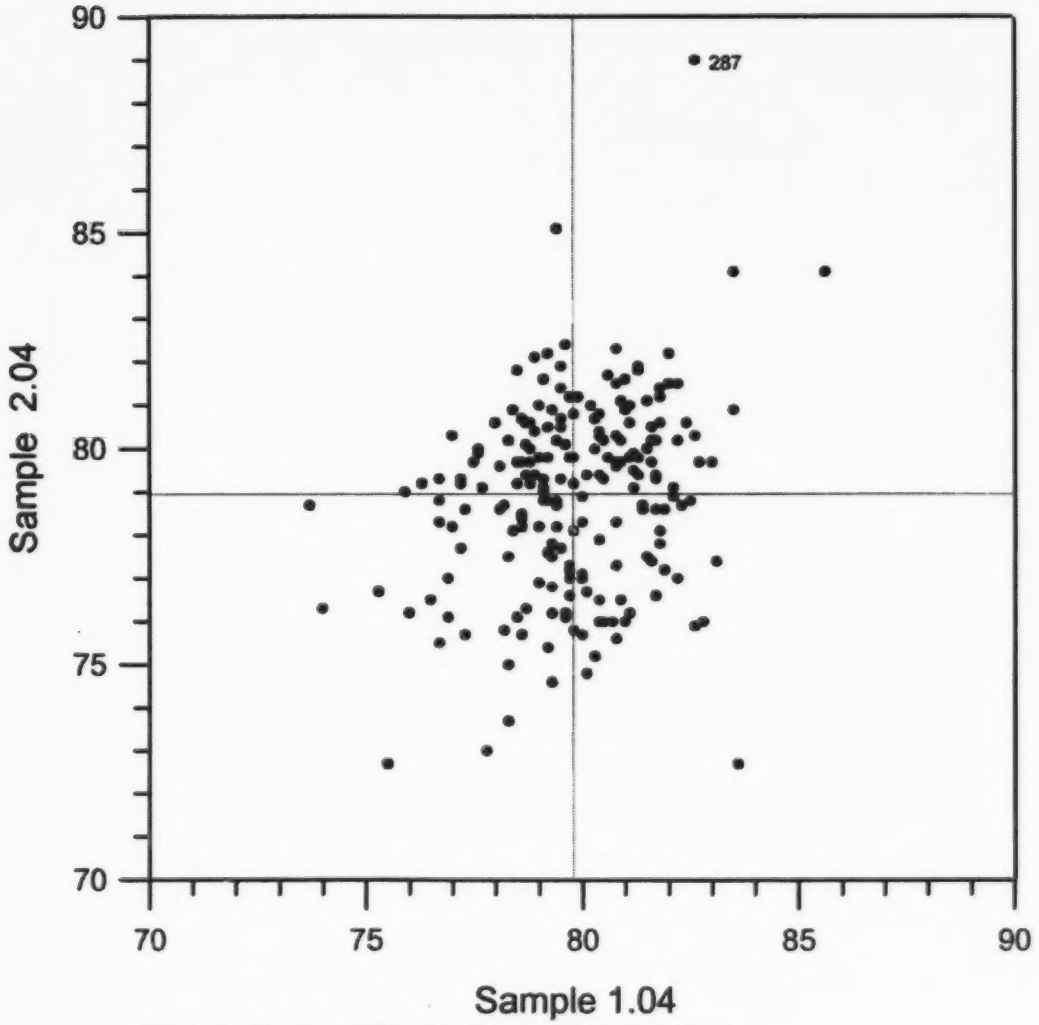


Test 3: Percent Passing the 16.0 mm Sieve

	Mat 1	Mat 2
Mean	89.476	89.037
Median	88.800	88.750
Std Dev	1.267	1.401
n = 203		

Lab Eliminated: 275

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

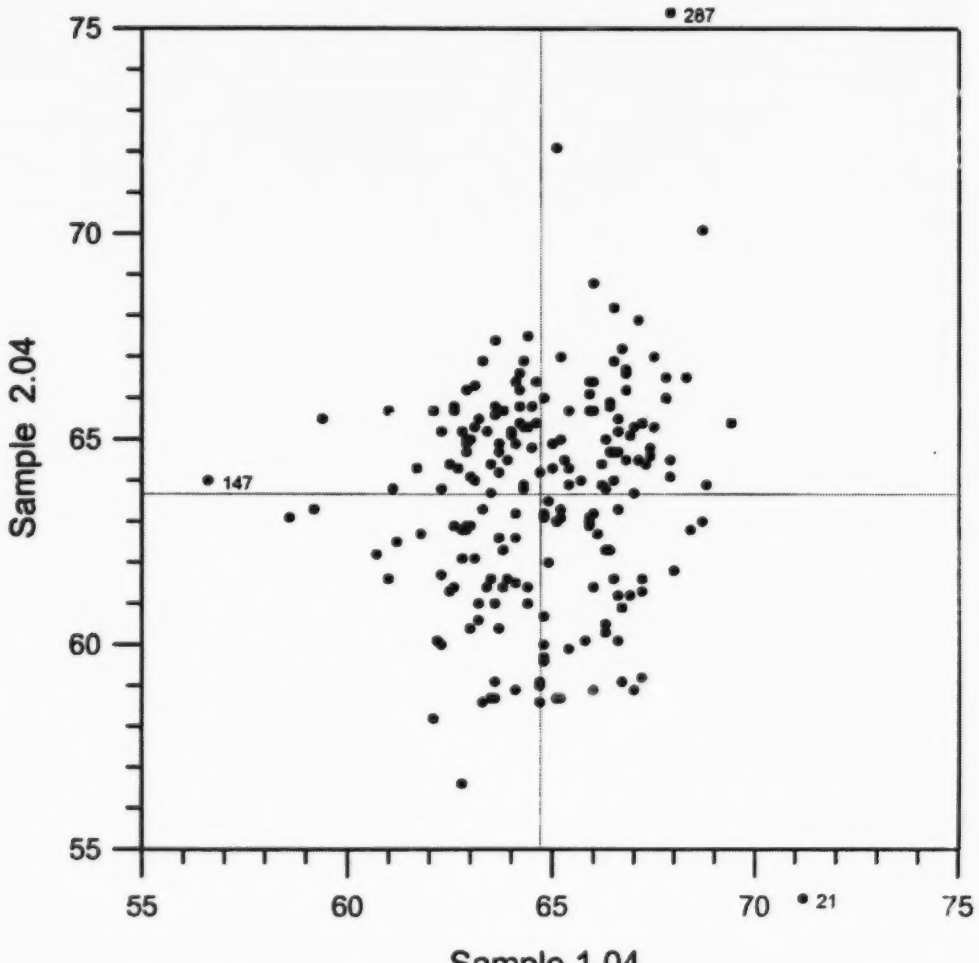


Test 4: Percent Passing the 13.2 mm Sieve

	Mat 1	Mat 2
Mean	79.793	78.895
Median	79.650	78.900
Std Dev	1.832	2.107
n = 203		

Lab Eliminated: 287

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

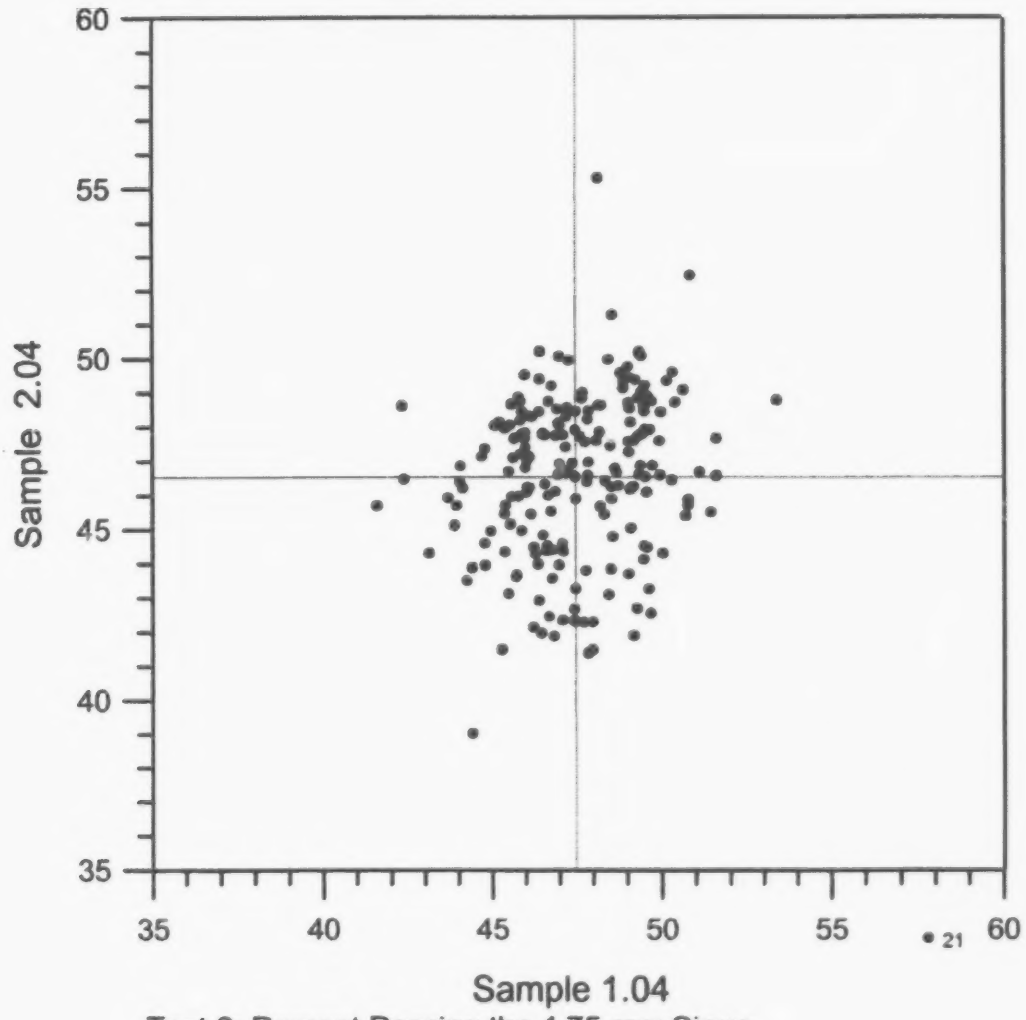


Test 5: Percent Passing the 9.5 mm Sieve

	Mat 1	Mat 2
Mean	64.803	63.646
Median	64.000	64.350
Std Dev	1.993	2.511
n = 201		

Labs Eliminated: 21, 147, 287

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

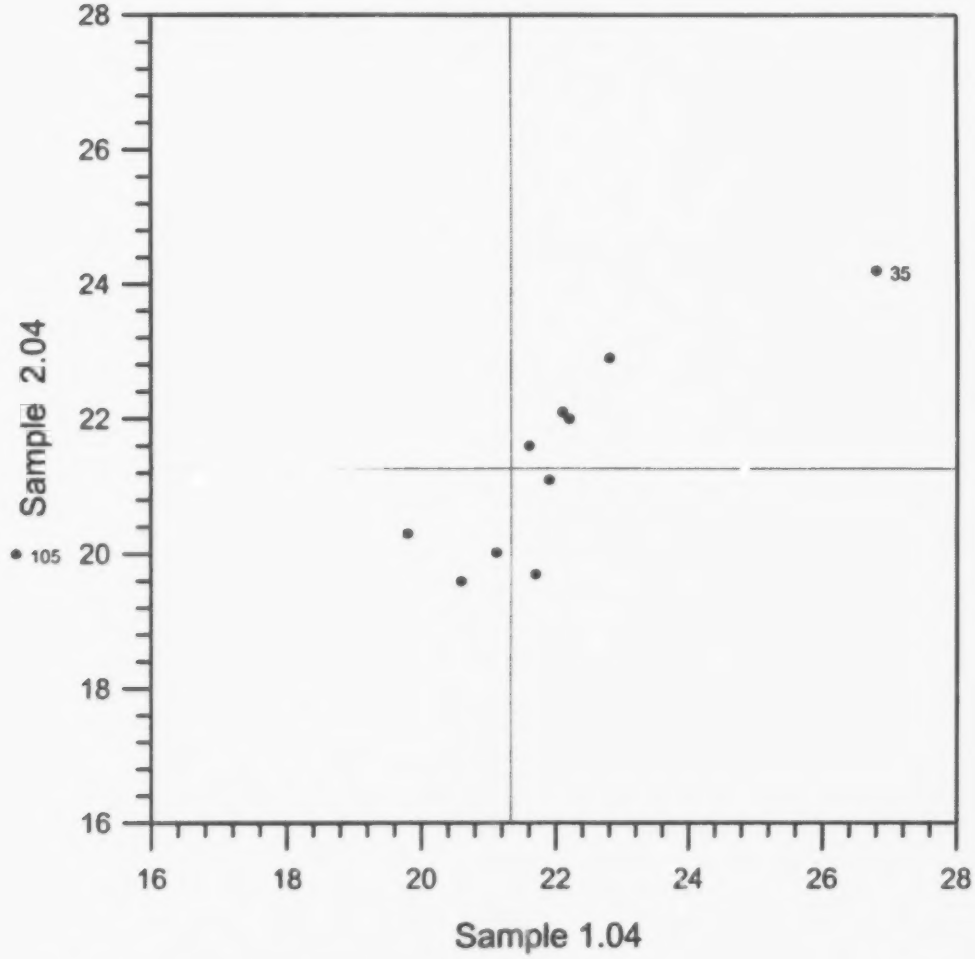


Test 6: Percent Passing the 4.75 mm Sieve

	Mat 1	Mat 2
Mean	47.494	46.566
Median	47.495	47.165
Std Dev	1.951	2.379
n = 203		

Lab Eliminated: 21

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

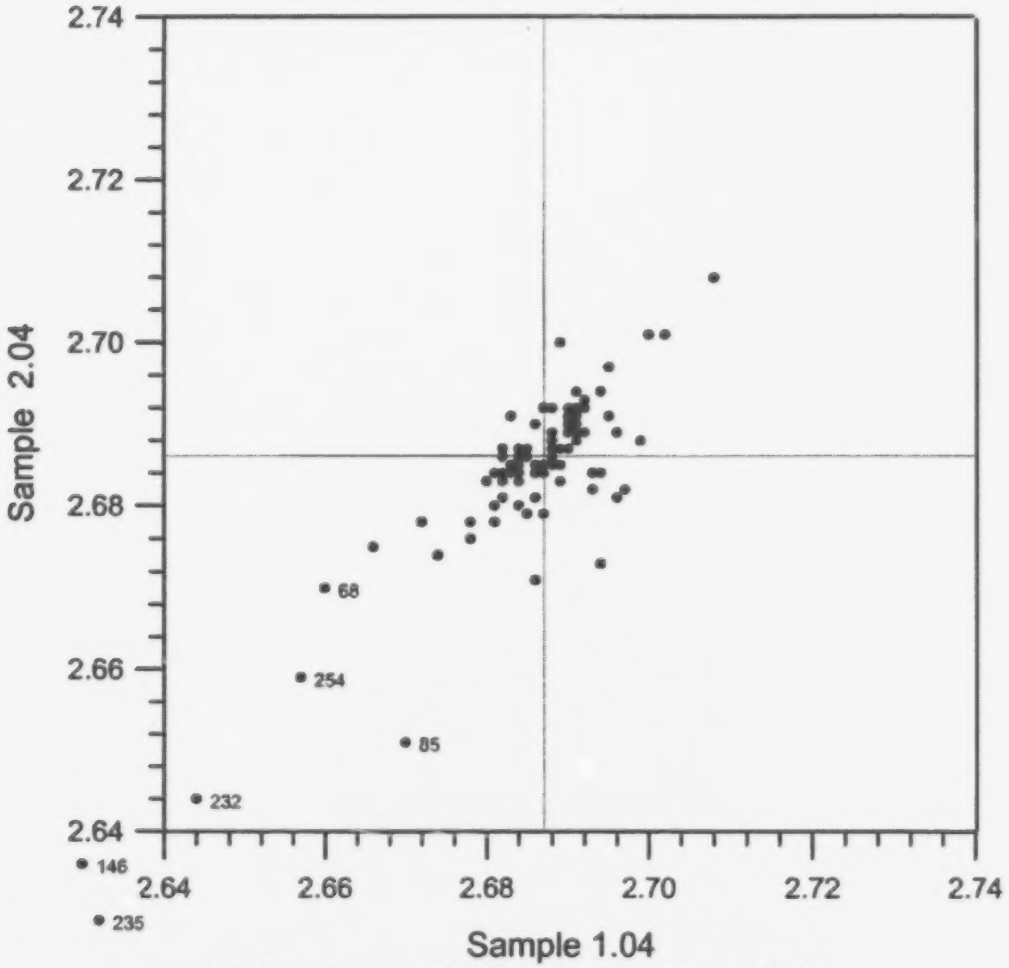


Test 8: Los Angeles Abrasion Loss, %

	Mat 1	Mat 2
Mean	21.536	21.275
Median	21.300	21.250
Std Dev	0.907	1.447
n = 9		

Labs Eliminated: 35, 105

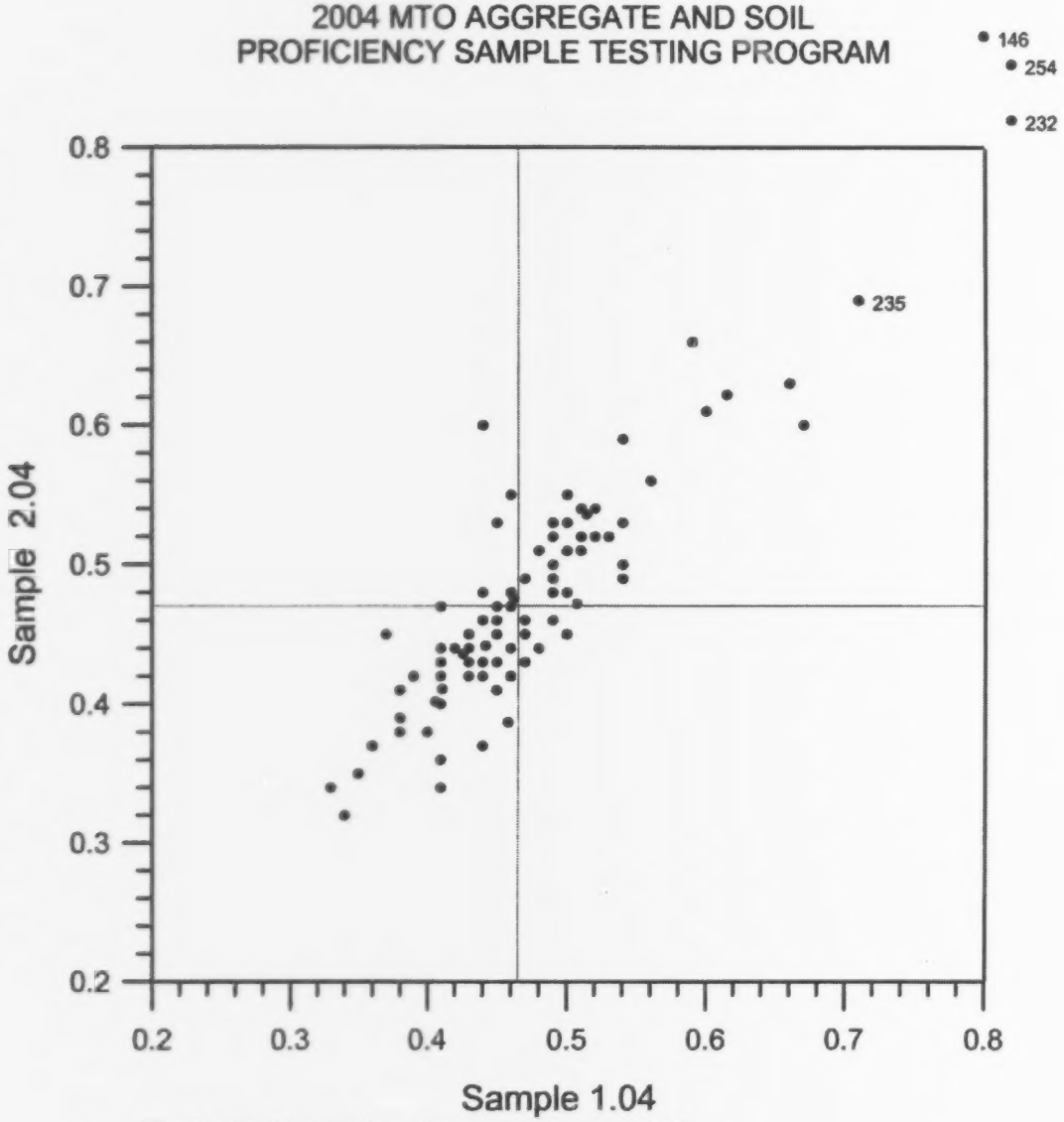
2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 9: Relative Density (Coarse Aggregate - Bulk)

	Mat 1	Mat 2
Mean	2.687	2.686
Median	2.687	2.690
Std Dev	0.006	0.006
n = 89		

Labs Eliminated: 68, 85, 146, 232, 235, 254

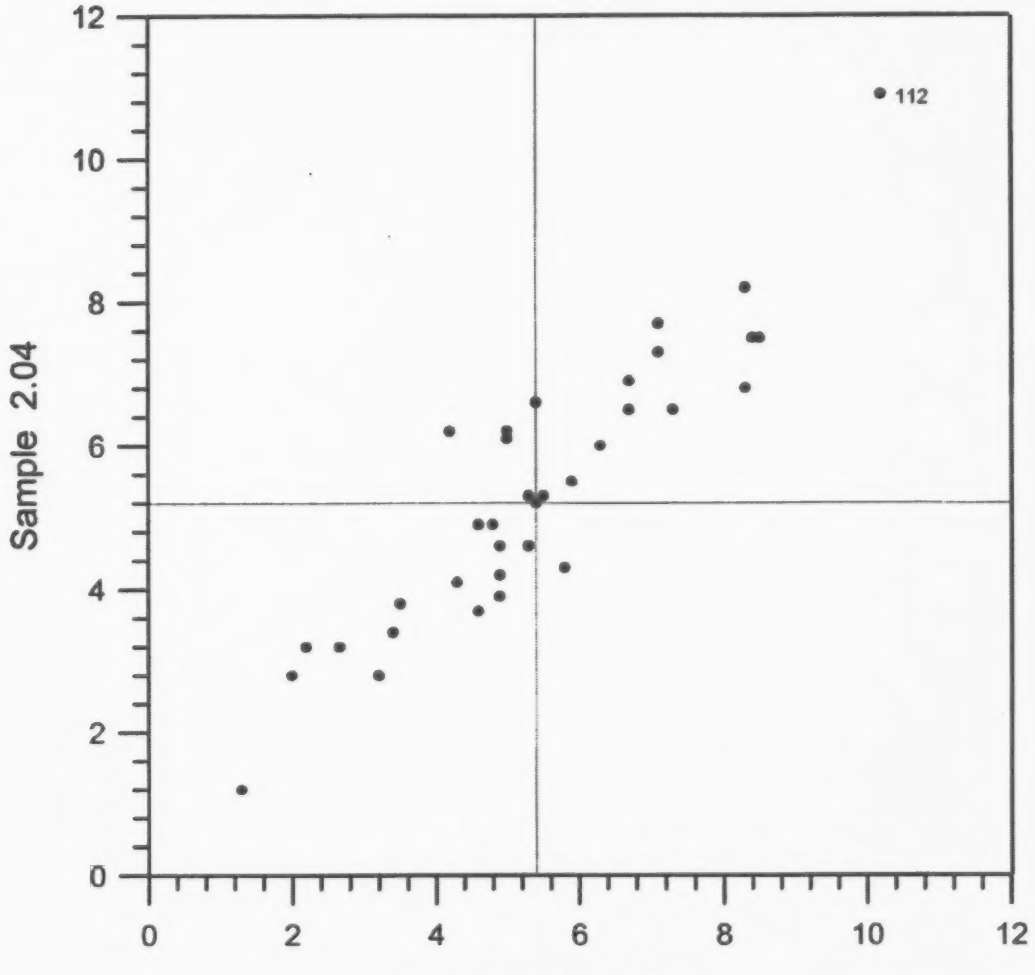


Test 10: Absorption (Coarse Aggregate)

	Mat 1	Mat 2
Mean	0.463	0.470
Median	0.500	0.490
Std Dev	0.064	0.073
n = 91		

Labs Eliminated: 146, 232, 235, 254

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

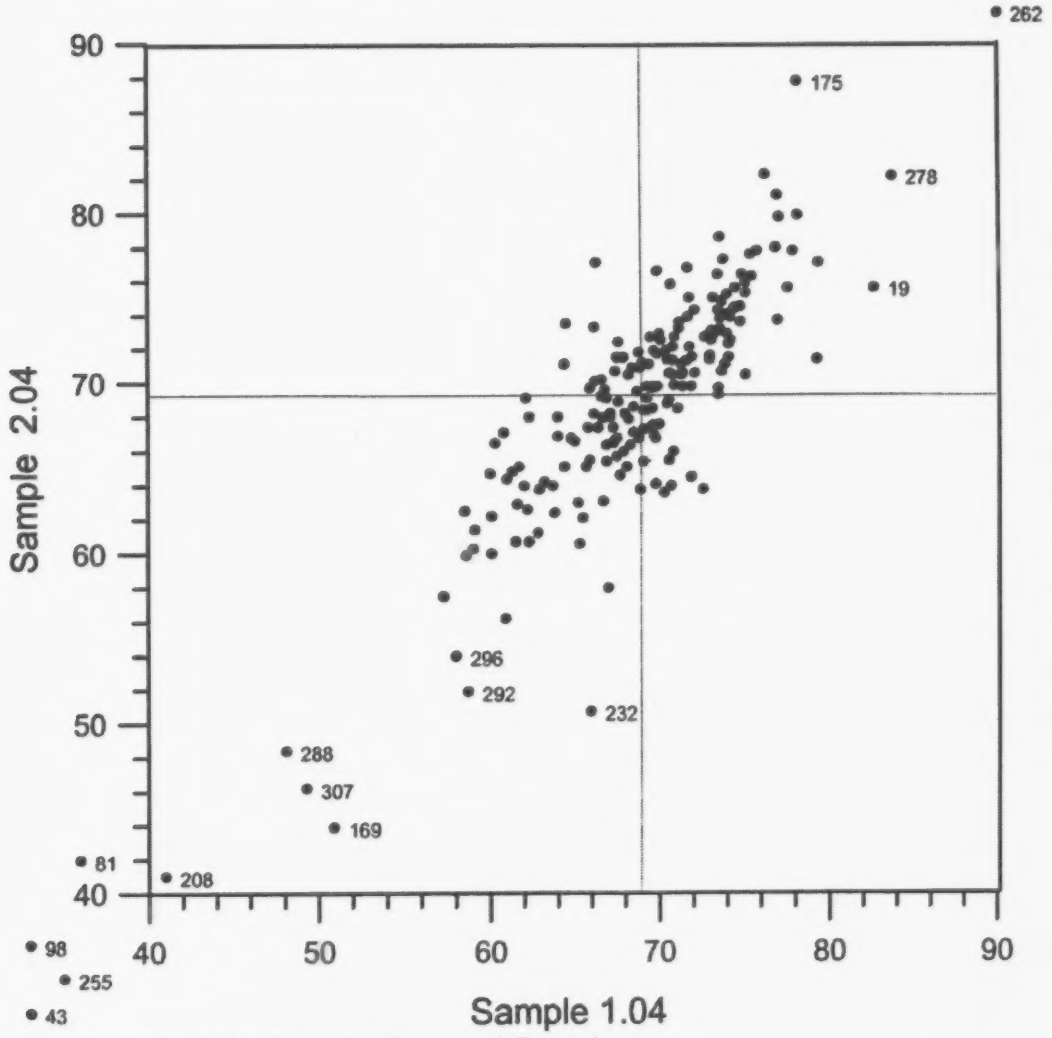


Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	5.399	5.203
Median	4.900	4.700
Std Dev	2.003	1.680
n = 34		

Lab Eliminated: 112

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

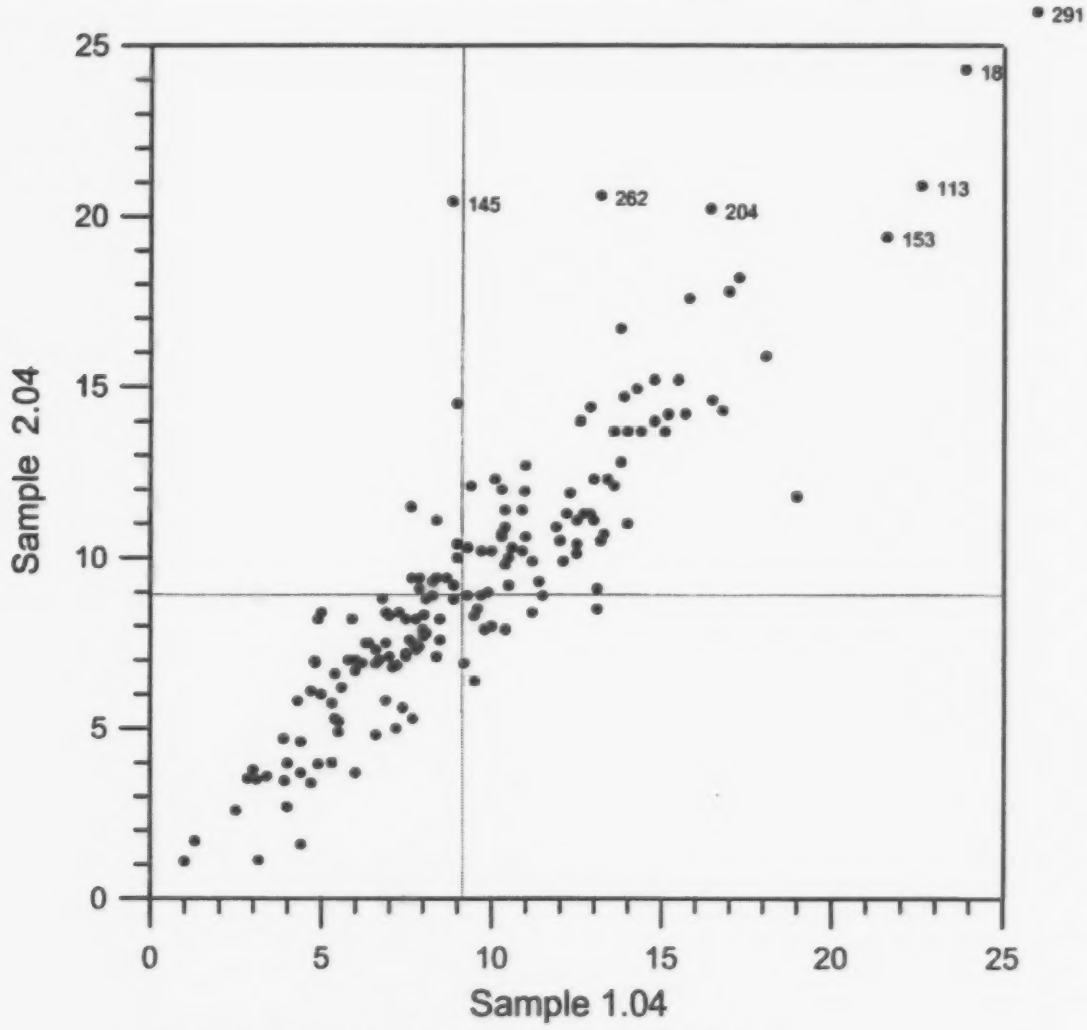


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	69.201	69.717
Median	68.350	69.250
Std Dev	4.757	4.920
n = 188		

Labs Eliminated: 19, 43, 81, 98, 169, 175, 208, 232
255, 262, 278, 288, 292, 296, 307

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

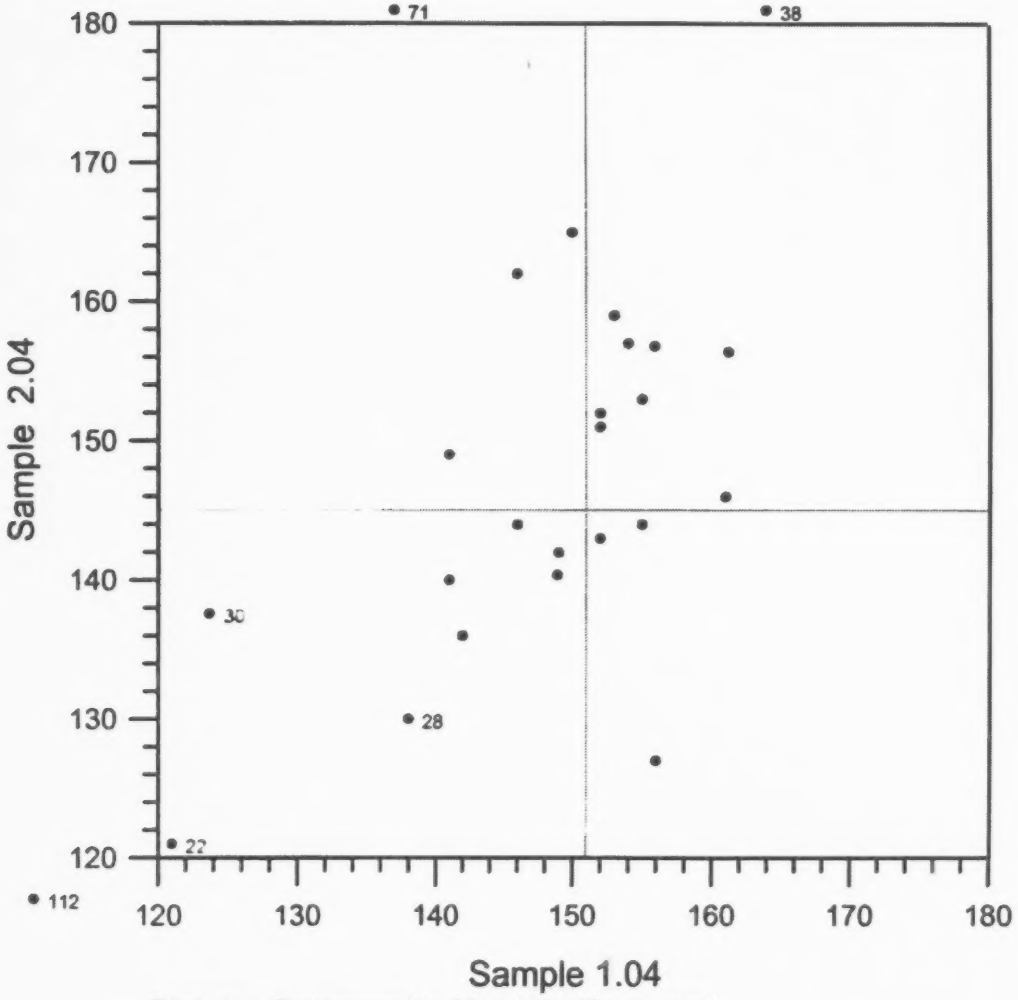


Test 13: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	9.199	8.946
Median	10.000	9.650
Std Dev	3.722	3.491
n = 160		

Labs Eliminated: 18, 113, 145, 153, 204, 262, 291

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

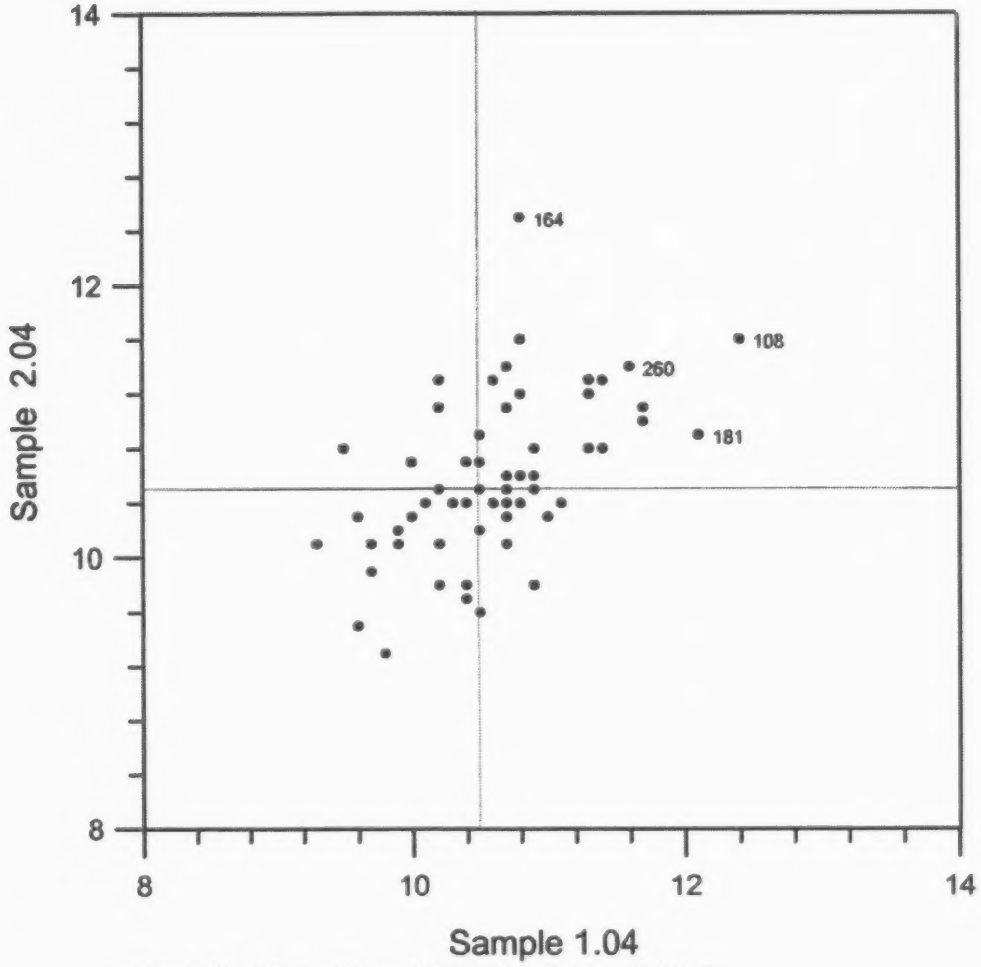


Test 14: Petrographic Number (Concrete)

	Mat 1	Mat 2
Mean	150.955	145.270
Median	151.100	146.000
Std Dev	6.936	12.344
n = 20		

Lab Eliminated: 22, 28, 30, 38, 71, 112

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

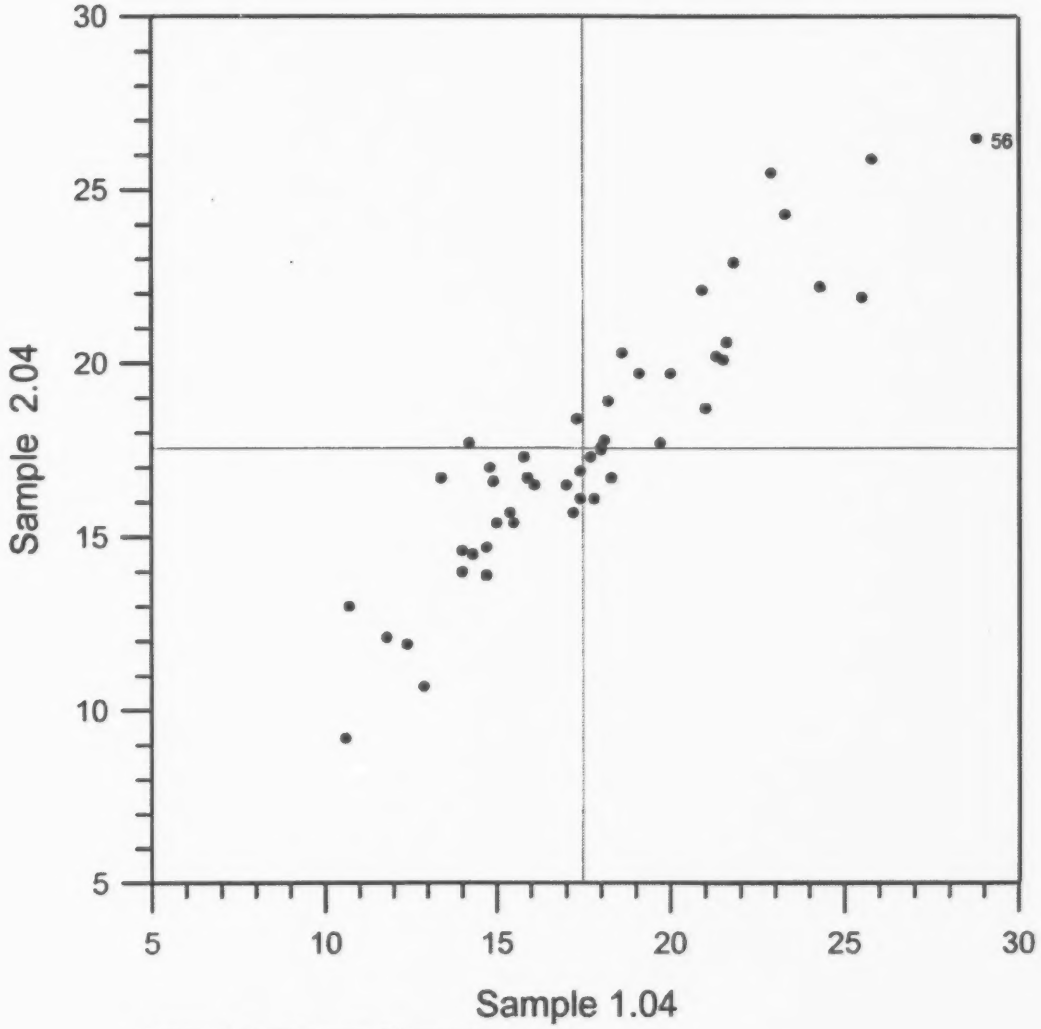


Test 16: Micro-Deval Abrasion Loss (CA), %

	Mat 1	Mat 2
Mean	10.529	10.535
Median	10.500	10.450
Std Dev	0.534	0.534
n = 58		

Labs eliminated by analysis: 108, 164, 181, 260

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

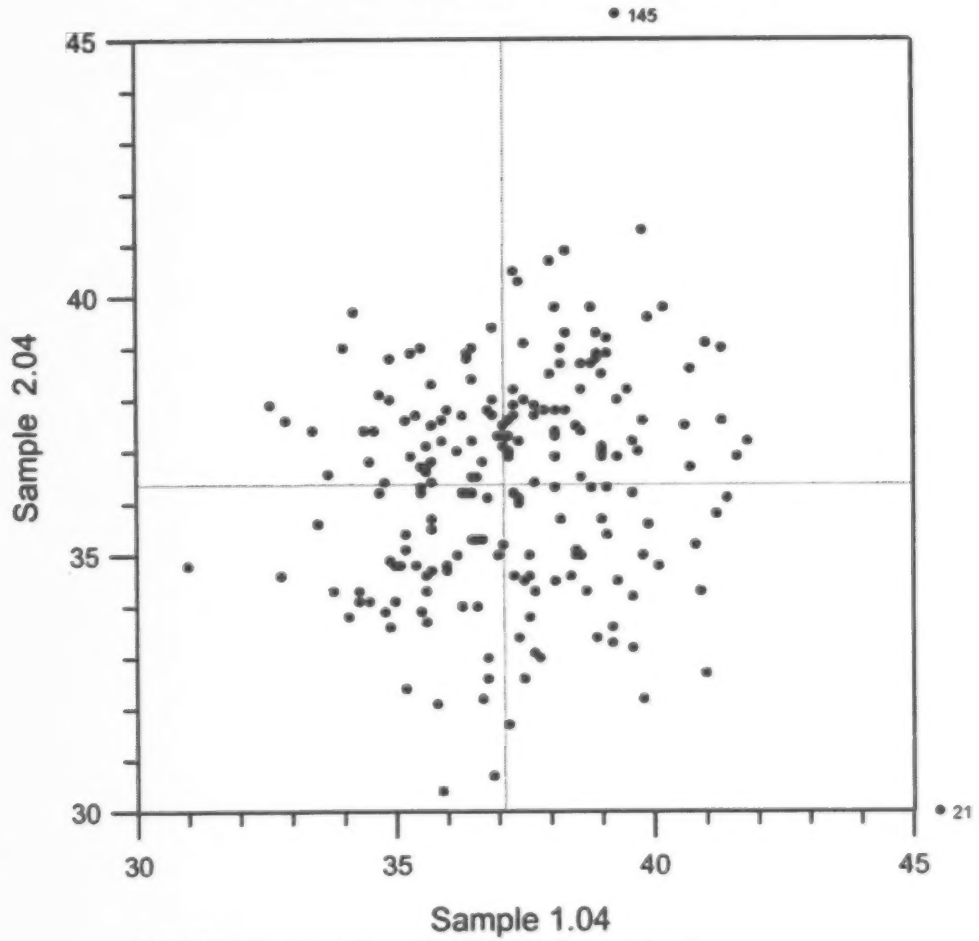


Test 17: Freeze-Thaw Loss, %

	Mat 1	Mat 2
Mean	17.464	17.654
Median	18.200	17.550
Std Dev	3.720	3.773
n = 47		

Lab eliminated: 56

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

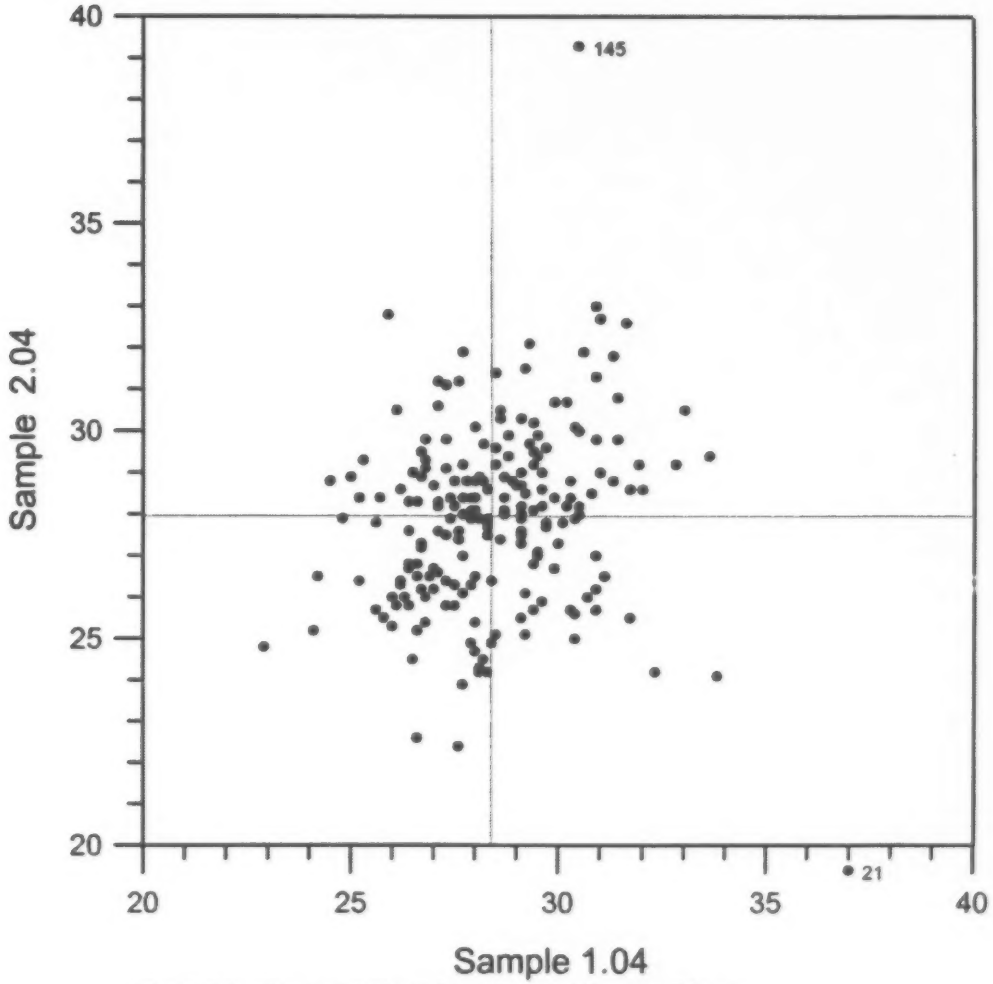


Test 20: Percent Passing the 2.36 mm Sieve

	Mat 1	Mat 2
Mean	37.232	36.394
Median	36.400	35.850
Std Dev	1.985	2.069
n = 202		

Labs Eliminated: 21, 145

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

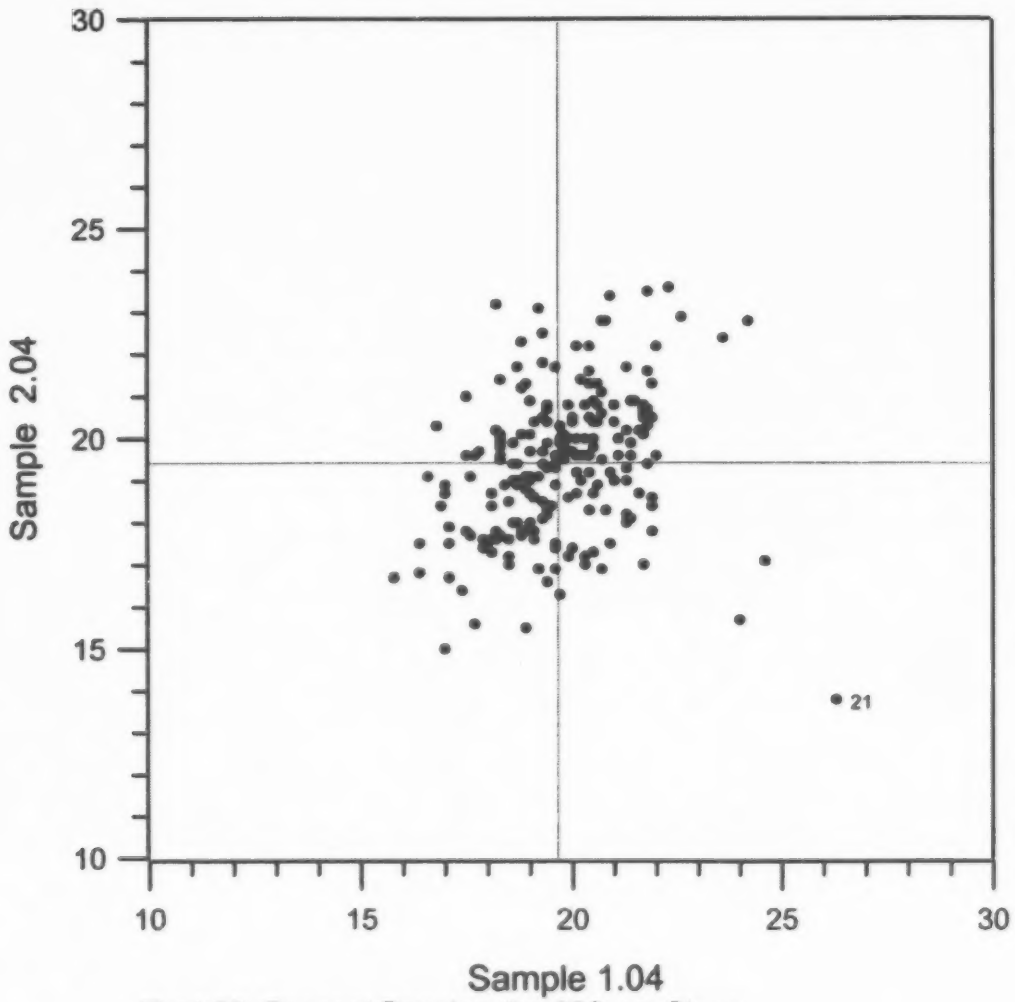


Test 21: Percent Passing the 1.18 mm Sieve

	Mat 1	Mat 2
Mean	28.412	27.909
Median	28.350	27.700
Std Dev	1.877	1.998
n = 202		

Labs Eliminated: 21, 145

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

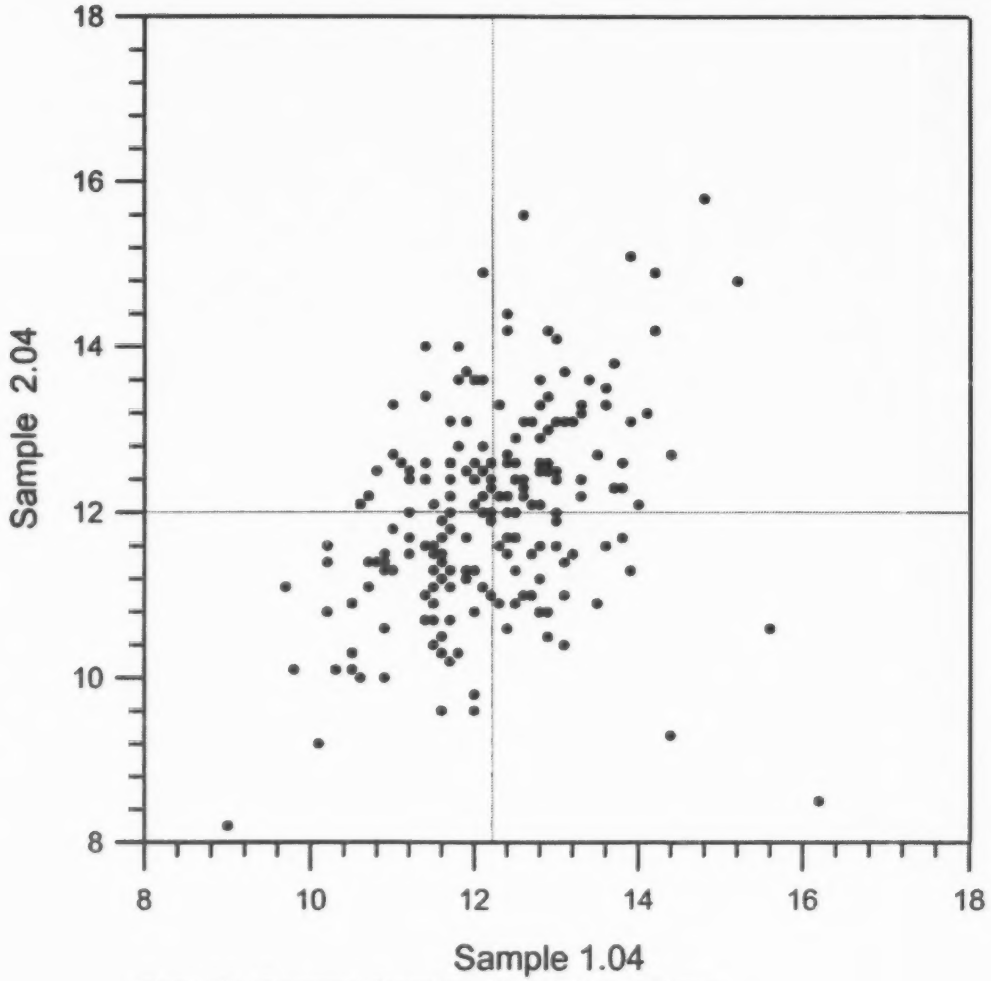


Test 22: Percent Passing the 600 um Sieve

	Mat 1	Mat 2
Mean	19.700	19.362
Median	20.200	19.300
Std Dev	1.524	1.724
n = 203		

Lab Eliminated: 21

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

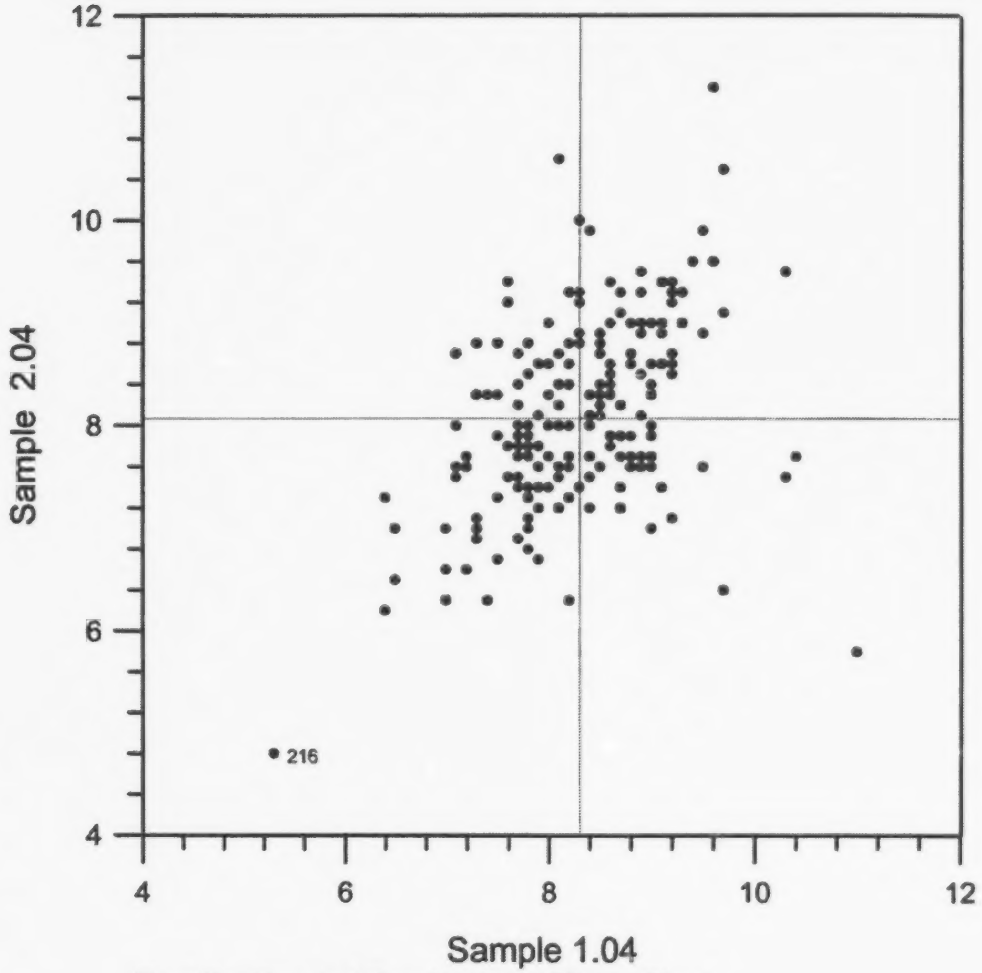


Test 23: Percent Passing the 300 um Sieve

	Mat 1	Mat 2
Mean	12.232	12.035
Median	12.600	12.000
Std Dev	1.074	1.237
n = 204		

Labs Eliminated: None

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

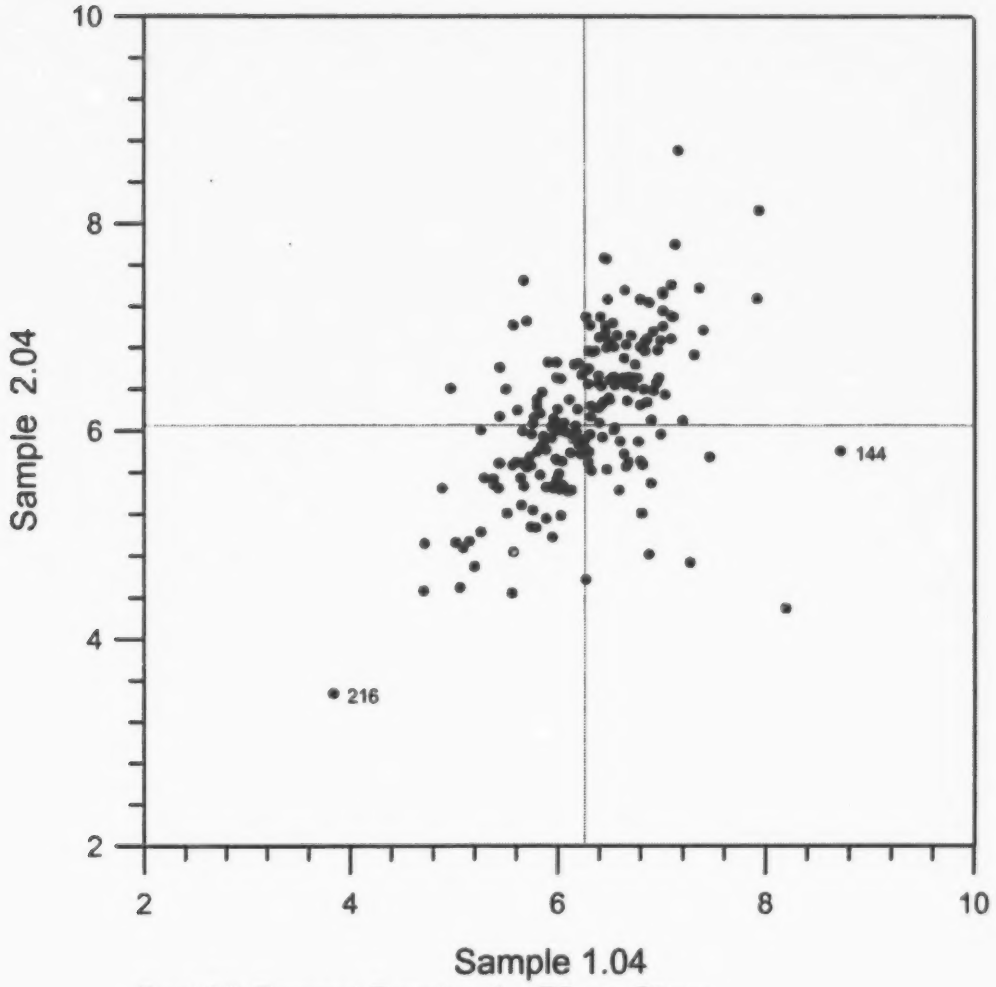


Test 24: Percent Passing the 150 um Sieve

	Mat 1	Mat 2
Mean	8.296	8.129
Median	8.700	8.550
Std Dev	0.749	0.907
n = 203		

Lab Eliminated: 216

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

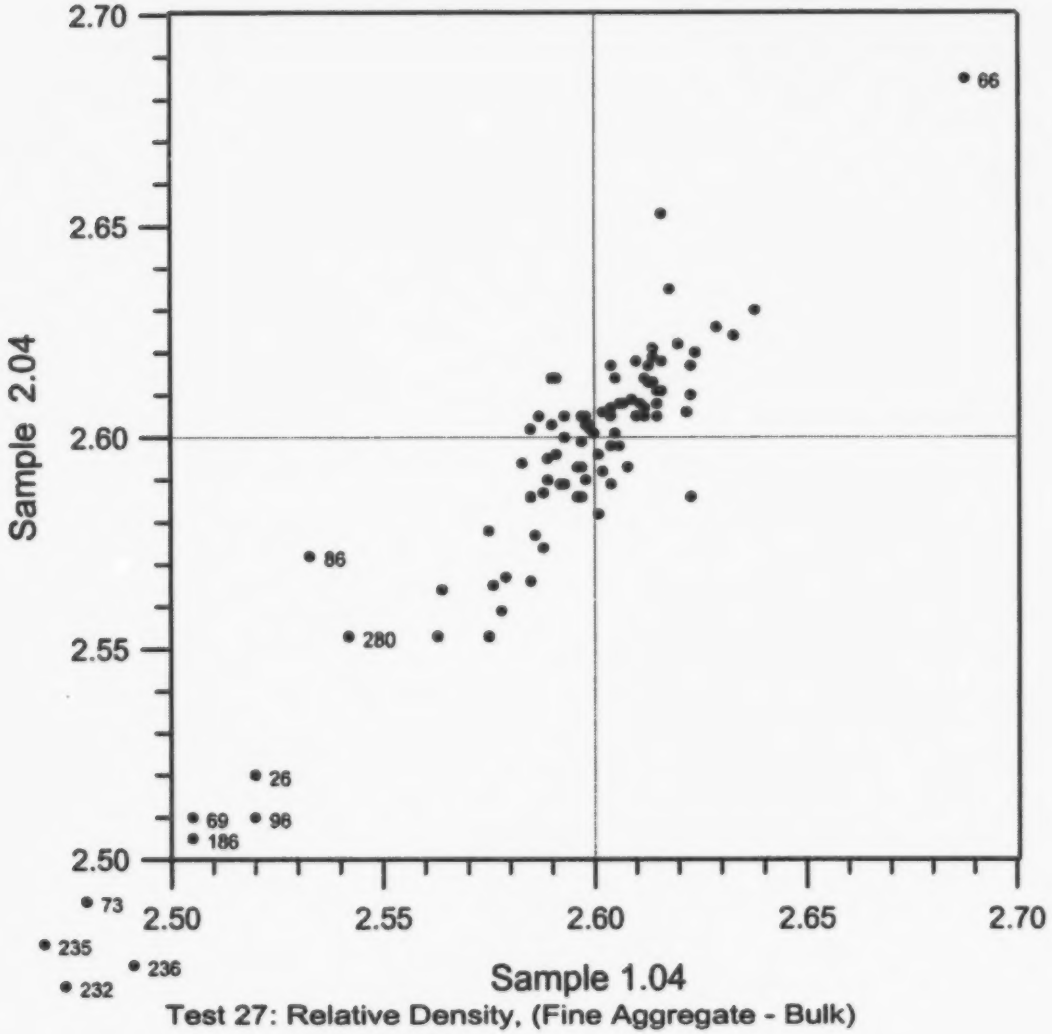


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	6.269	6.144
Median	6.455	6.505
Std Dev	0.602	0.758
n = 202		

Labs Eliminated: 144, 216

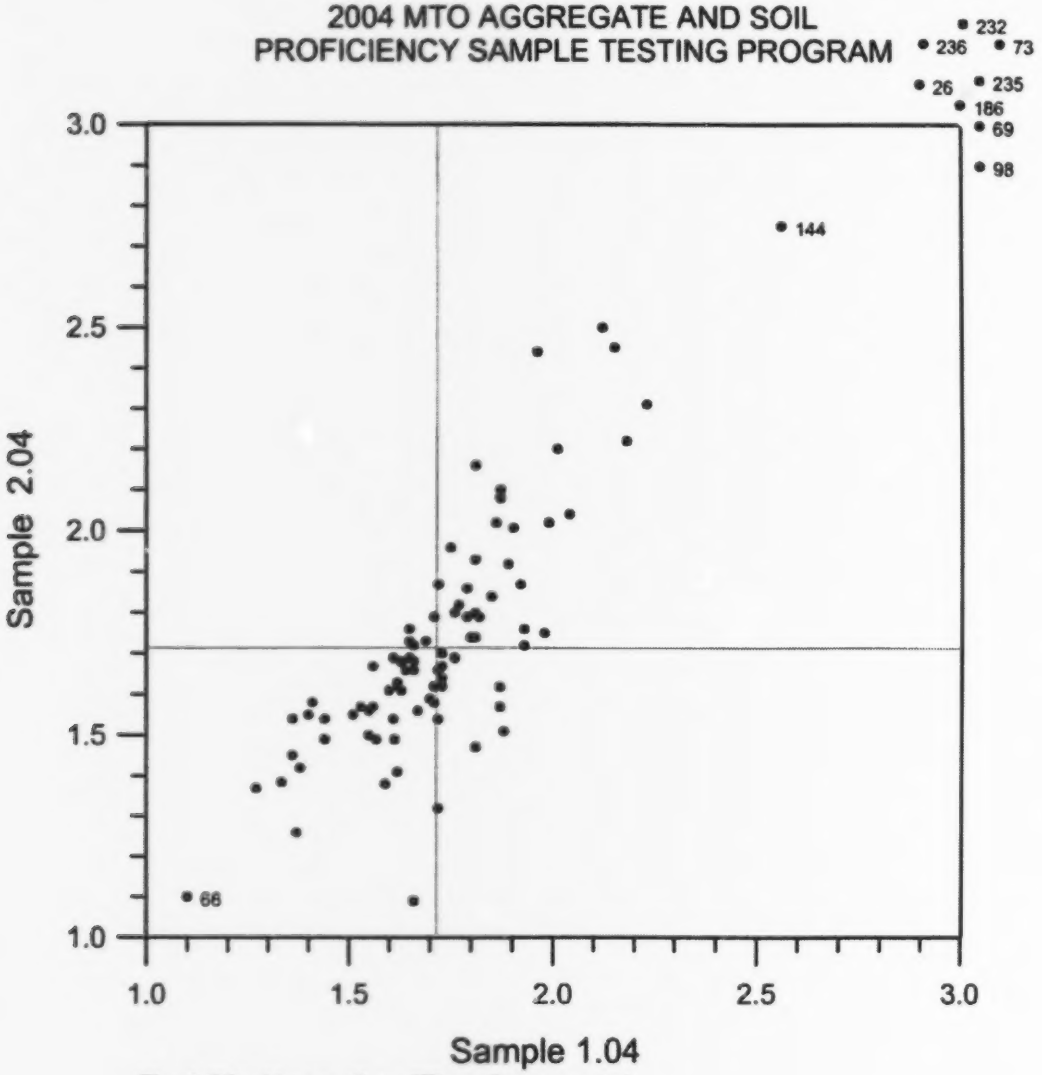
2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 27: Relative Density, (Fine Aggregate - Bulk)

	Mat 1	Mat 2
Mean	2.602	2.600
Median	2.601	2.603
Std Dev	0.015	0.019
n = 82		

Labs Eliminated: 26, 66, 69, 73, 86, 98, 186, 232, 235, 236, 280

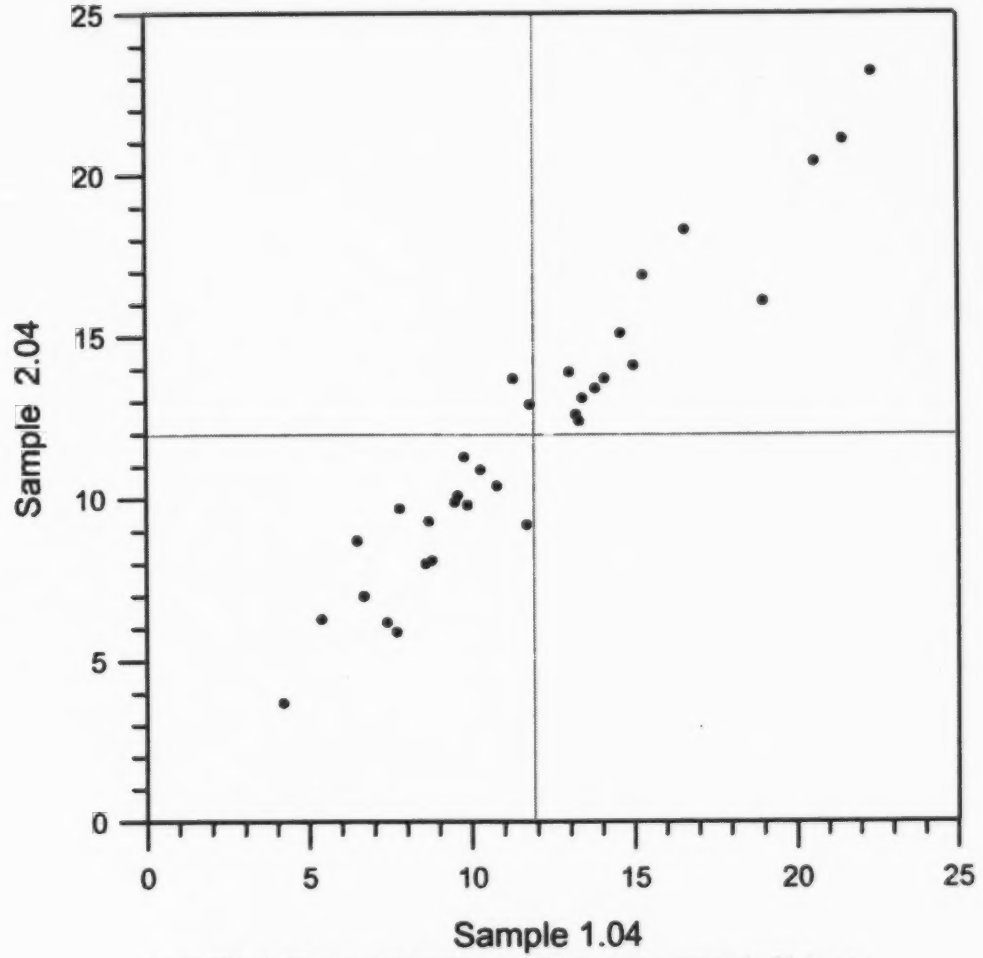


Test 28: Absorption (Fine Aggregate)

	Mat 1	Mat 2
Mean	1.717	1.719
Median	1.750	1.795
Std Dev	0.197	0.302
n = 83		

Labs Eliminated: 26, 66, 69, 73, 98, 144, 186, 232, 235, 236

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

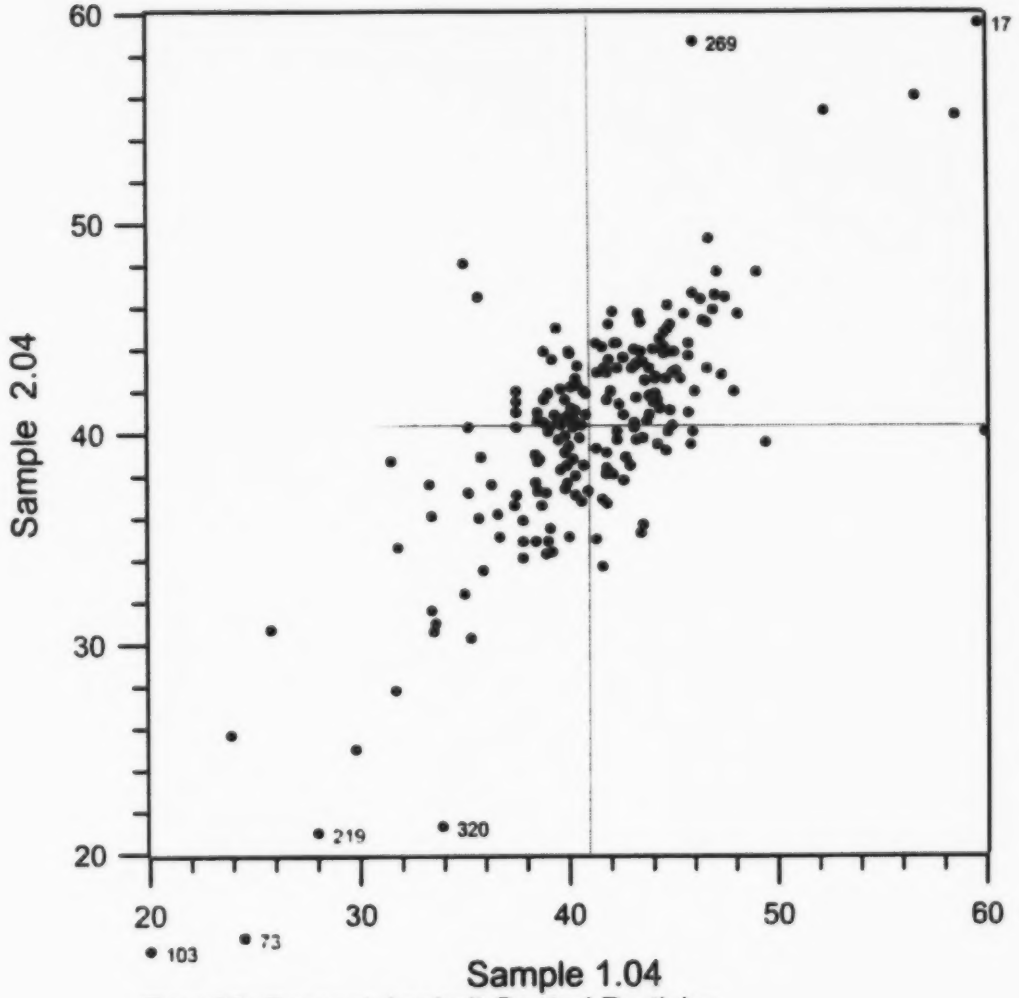


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	11.888	11.982
Median	13.300	13.450
Std Dev	4.546	4.555
n = 33		

Lab Eliminated: None

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

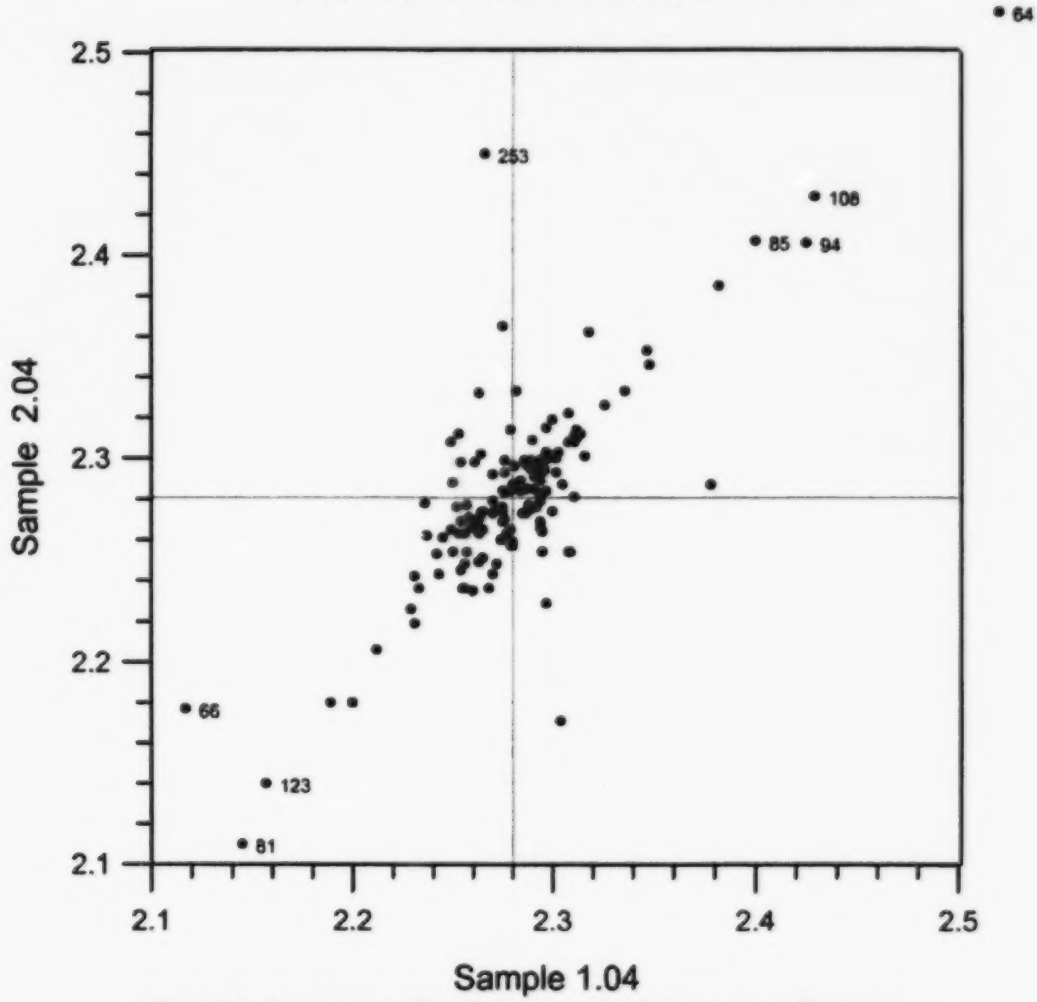


Test 30: Percent Asphalt Coated Particles

	Mat 1	Mat 2
Mean	41.325	40.598
Median	41.900	40.550
Std Dev	4.956	4.443
n = 196		

Labs Eliminated: 17, 73, 103, 219, 269, 320

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

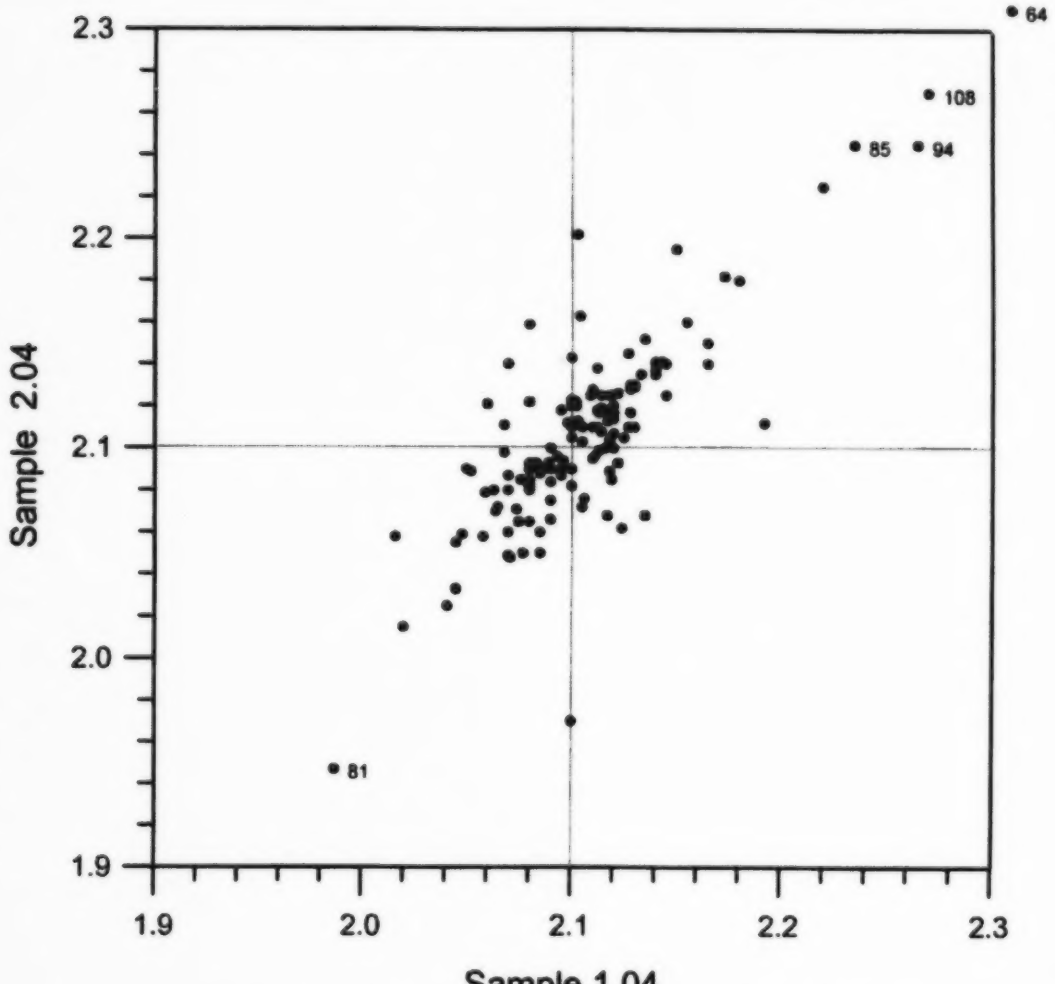


Test 31: Maximum Wet Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.280	2.281
Median	2.286	2.278
Std Dev	0.029	0.041
n = 133		

Labs Eliminated: 64, 66, 81, 85, 94, 108, 123, 253

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

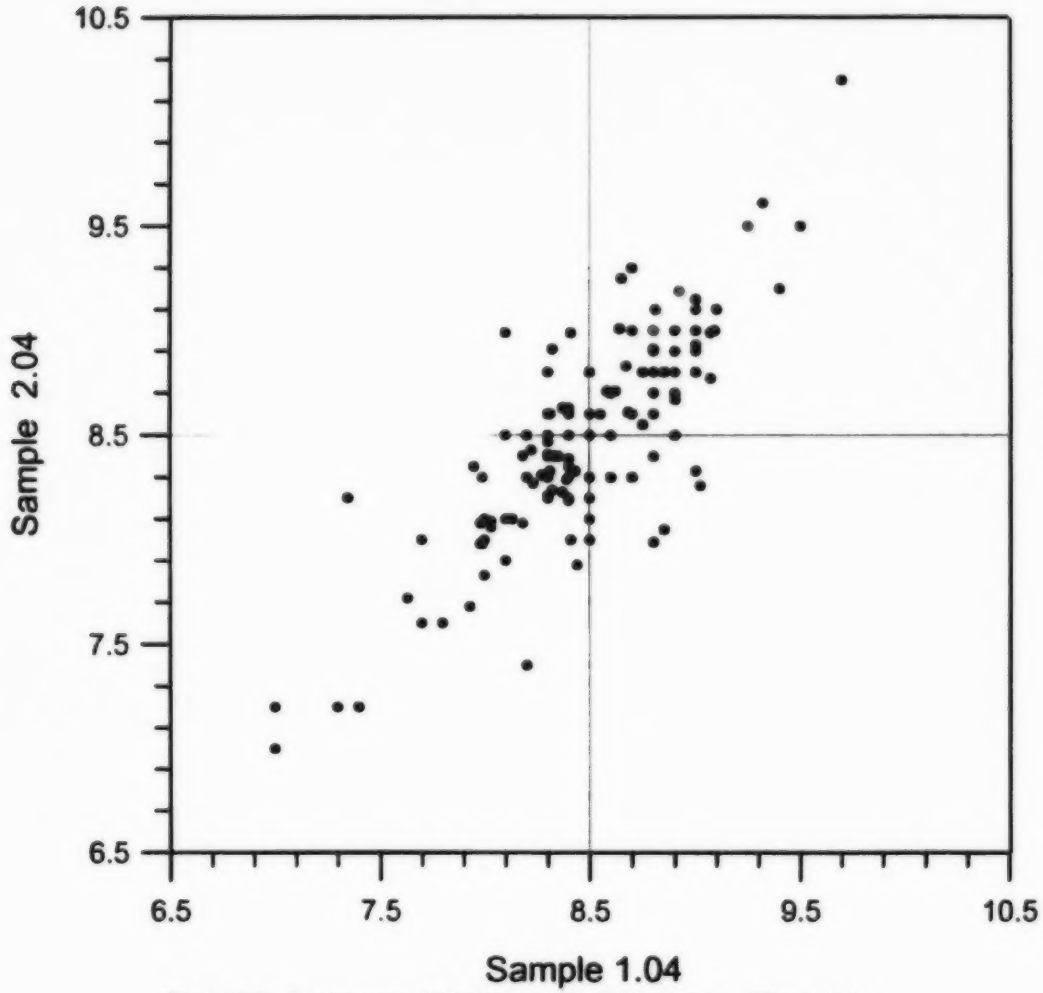


Test 32: Maximum Dry Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.102	2.105
Median	2.118	2.098
Std Dev	0.033	0.040
n = 136		

Labs Eliminated: 64, 81, 85, 94, 108

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

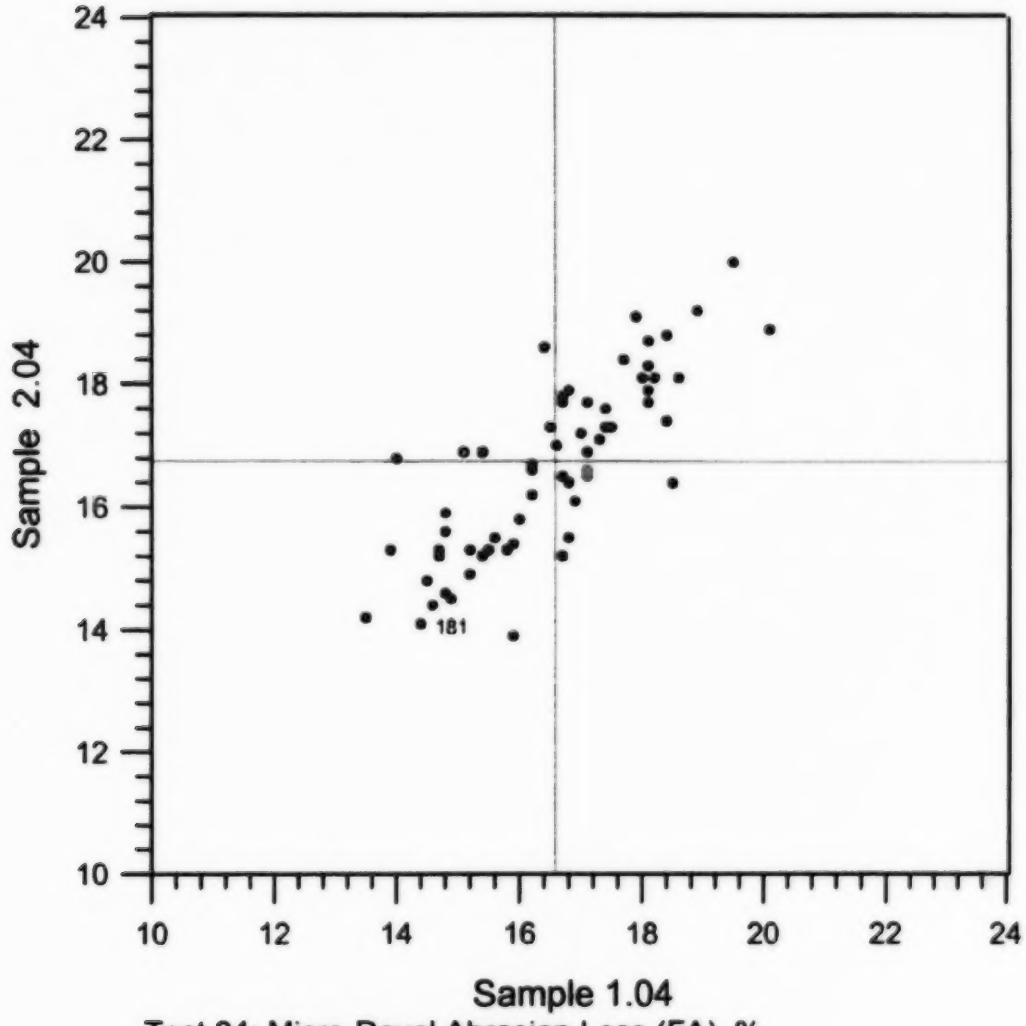


Test 33: Optimum Moisture, % (Moisture - Density)

	Mat 1	Mat 2
Mean	8.469	8.479
Median	8.350	8.600
Std Dev	0.451	0.490
n = 141		

Labs Eliminated: None

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

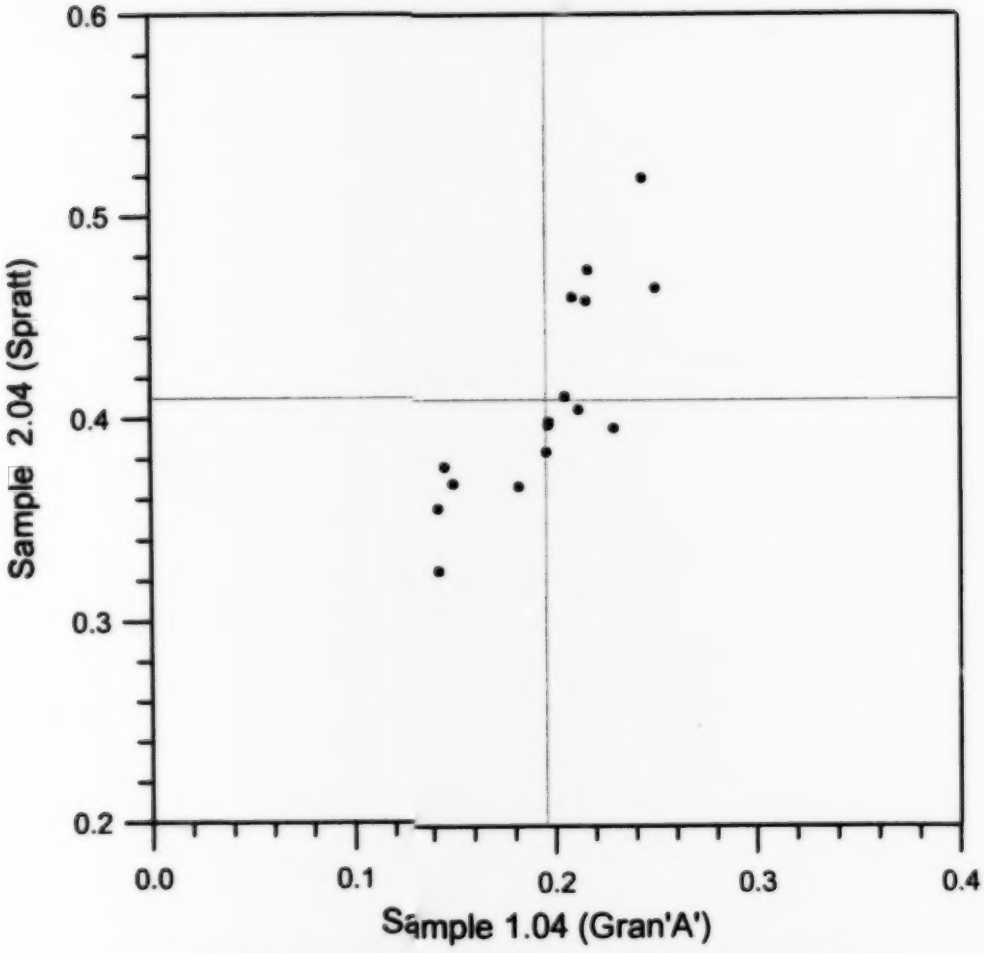


Test 34: Micro-Deval Abrasion Loss (FA), %

	Mat 1	Mat 2
Mean	16.597	16.731
Median	16.800	16.950
Std Dev	1.468	1.447
n = 61		

Lab eliminated: 181

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

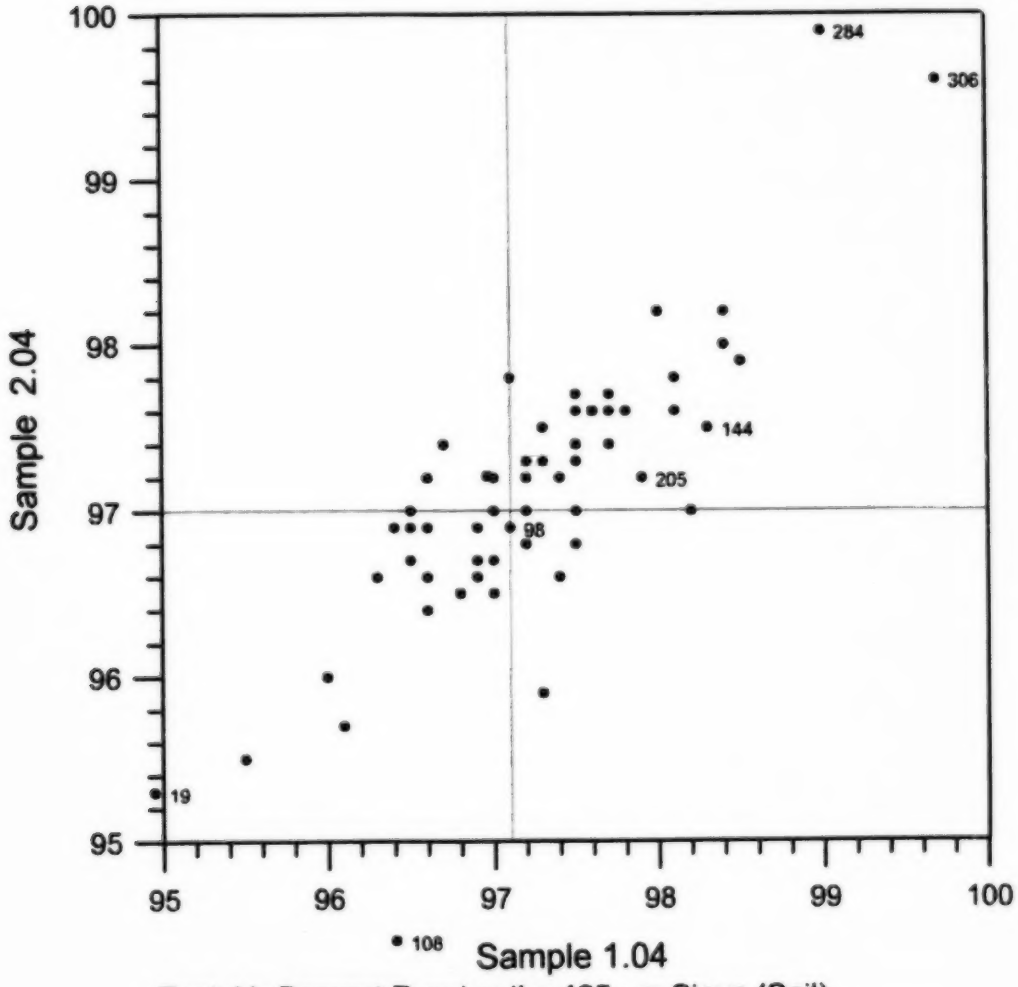


Test 123: Accelerated Mortar Bar - 14 Days in NaOH

	Gran 'A'	Spratt
Mean	0.196	0.410
Median	0.196	0.423
Std Dev	0.035	0.051
n = 16		

Labs Eliminated: None

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

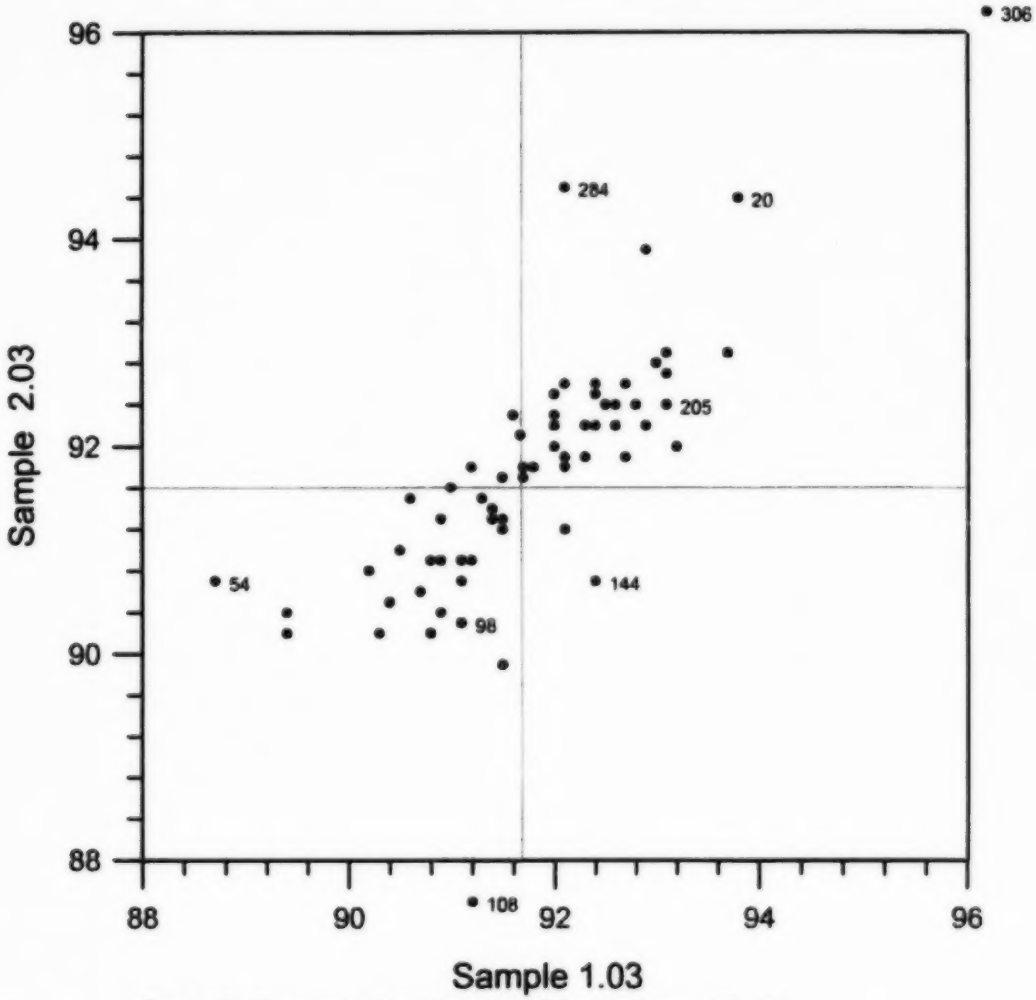


Test 41: Percent Passing the 425 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	97.133	96.995
Median	97.000	96.850
Std Dev	0.610	0.610
n = 60		

Labs eliminated: 19, 98, 108, 144, 205, 284, 306

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

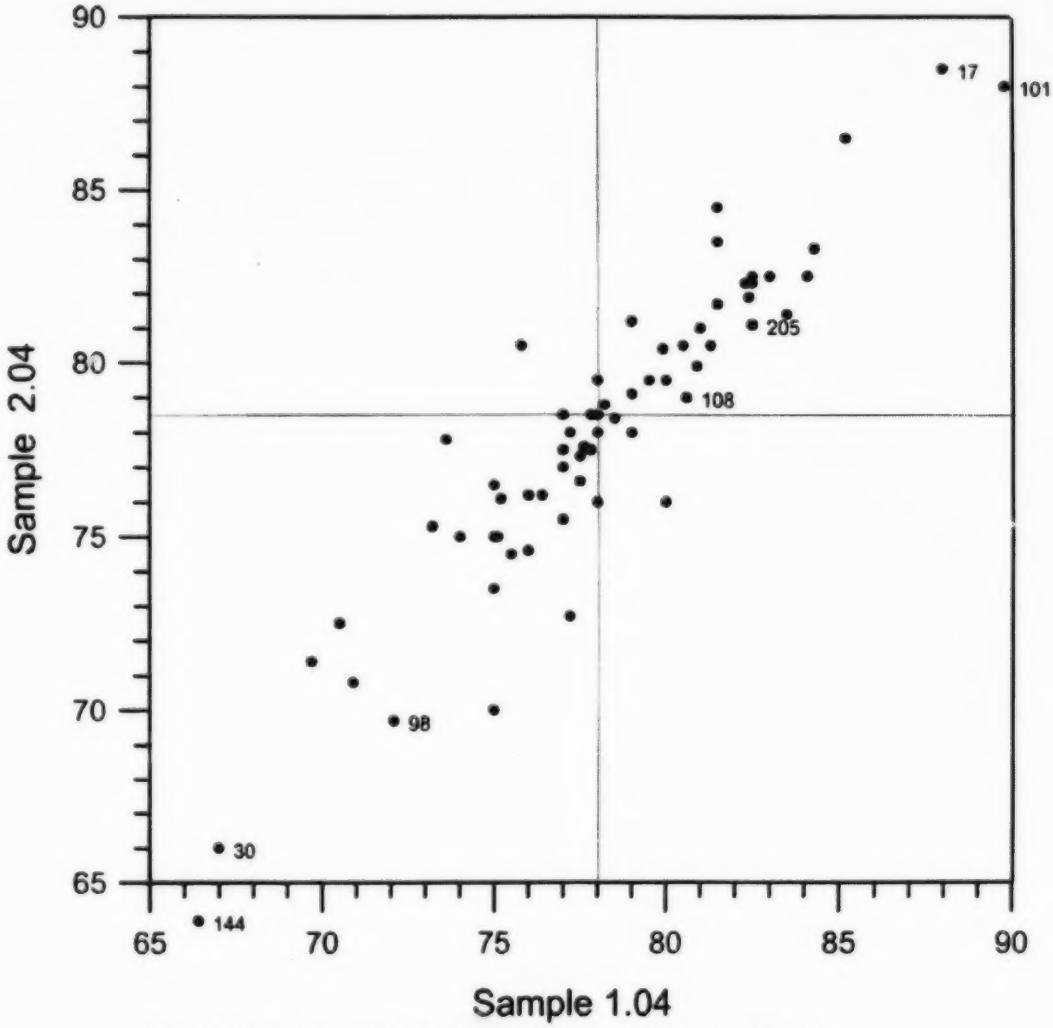


Test 42: Percent Passing the 75 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	91.767	91.667
Median	91.550	91.900
Std Dev	0.950	0.835
n = 59		

Labs eliminated: 20, 54, 98, 108, 144, 205, 284, 306

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

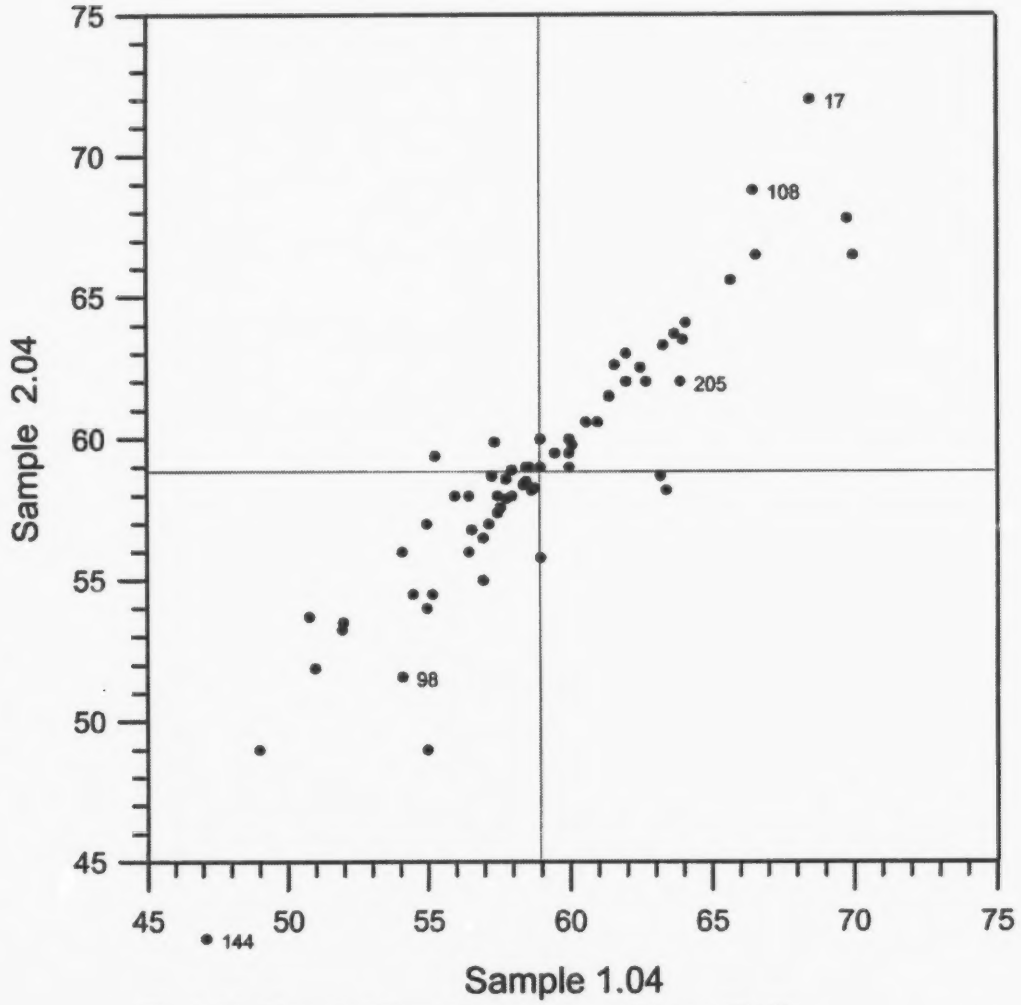


Test 43: Percent Passing the 20 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	78.137	78.489
Median	77.450	78.250
Std Dev	3.356	3.823
n = 60		

Labs eliminated: 17, 30, 98, 101, 108, 144, 205

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

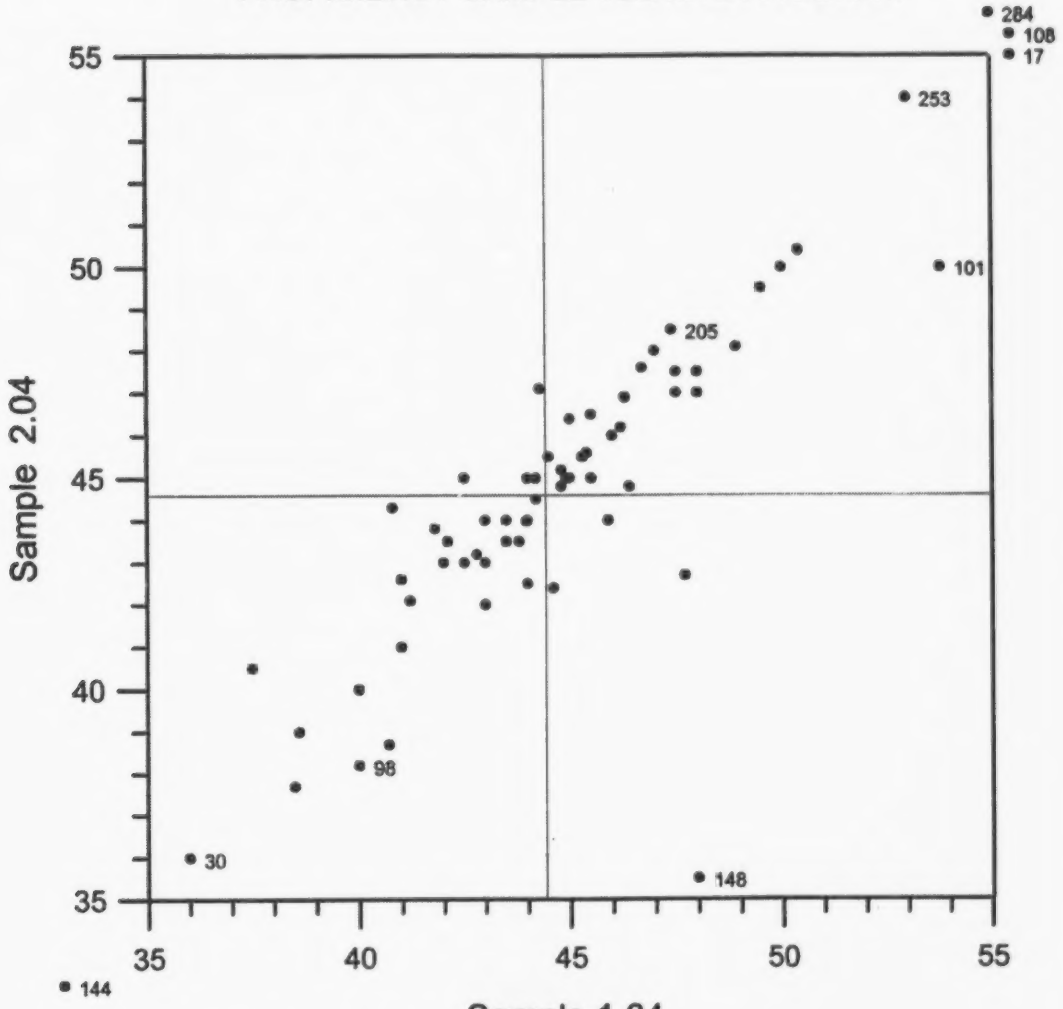


Test 44: Percent Passing the 5 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	59.004	58.770
Median	59.500	58.400
Std Dev	4.277	3.789
n = 62		

Labs eliminated: 17, 98, 108, 144, 205

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

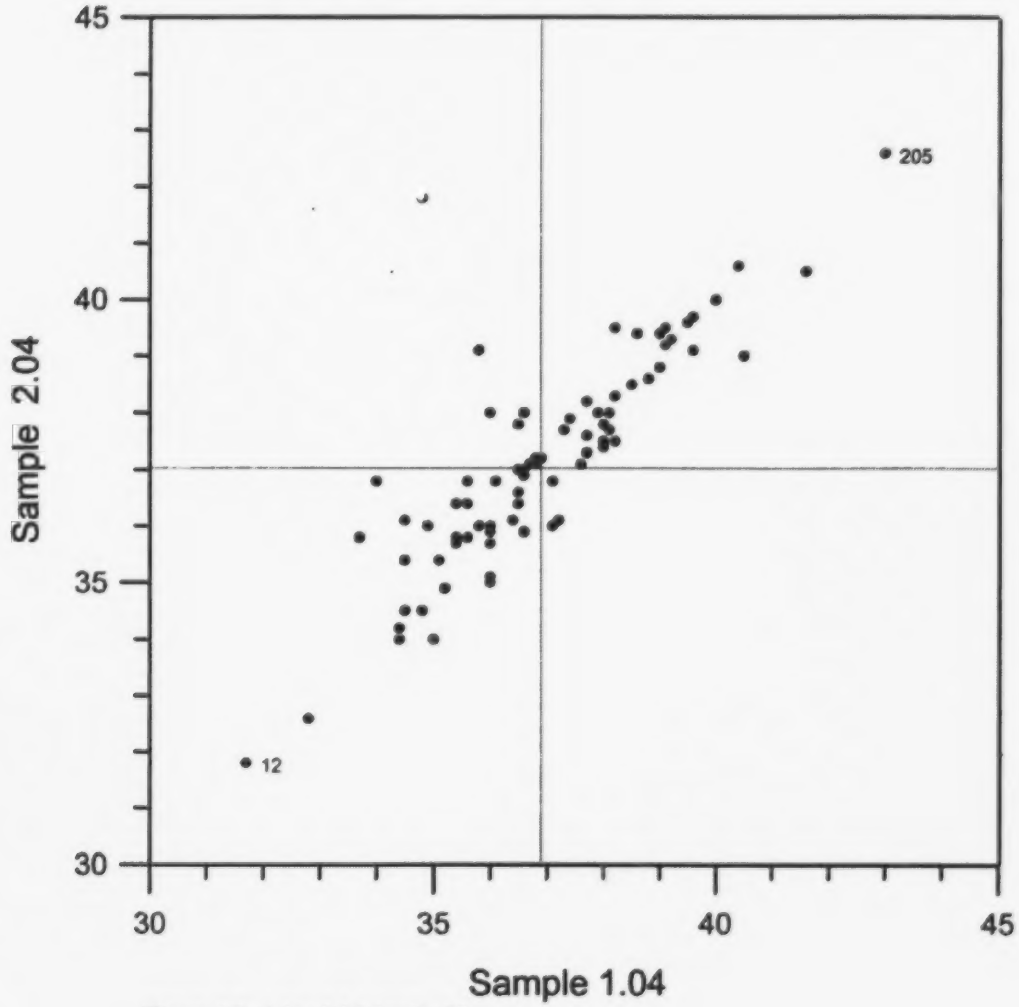


Test 45: Percent Passing the 2 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	44.393	44.596
Median	43.950	44.050
Std Dev	2.809	2.719
n = 57		

LabsEliminated: 17, 30, 98, 101, 108, 144, 148, 205, 253, 284

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

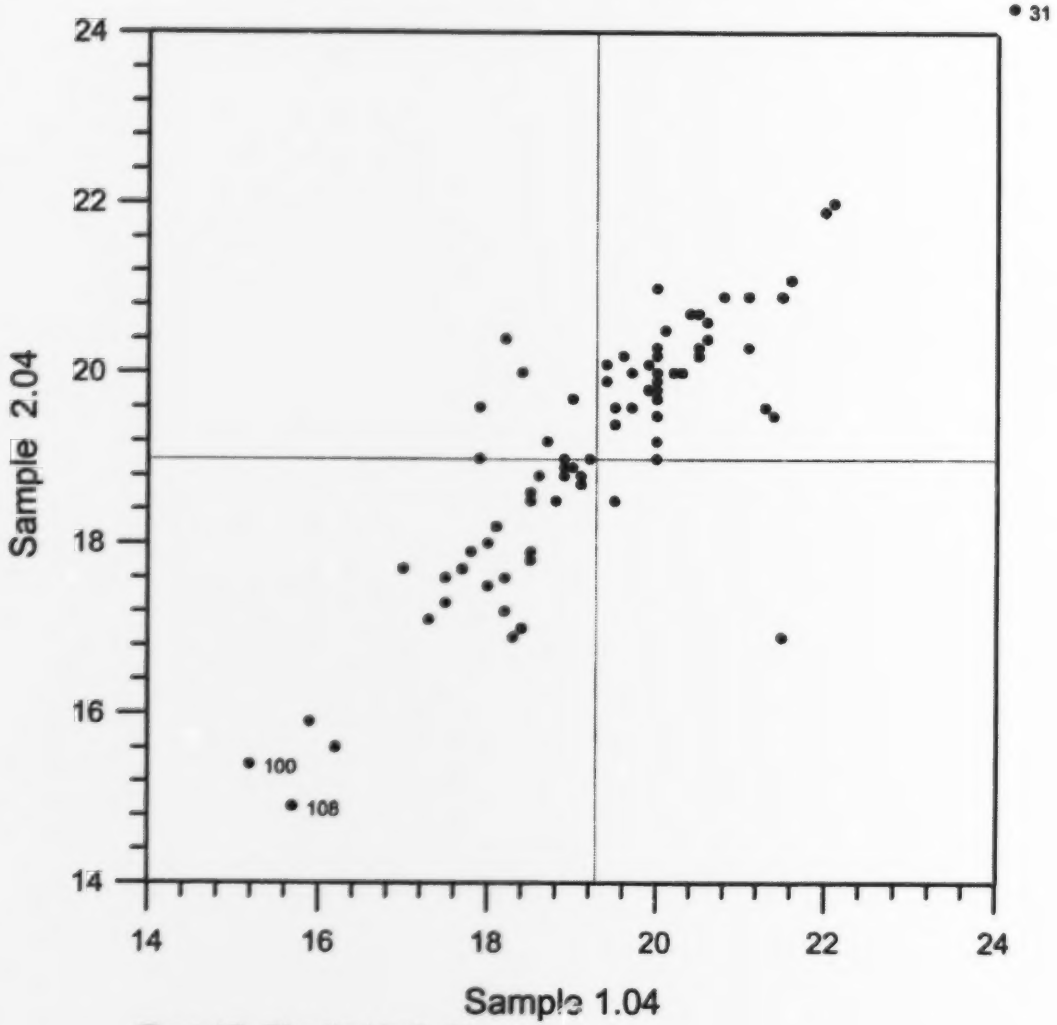


Test 46: Liquid Limit, %

	Mat 1	Mat 2
Mean	36.897	37.179
Median	37.200	37.200
Std Dev	1.784	1.756
n = 75		

Labs eliminated: 12, 205

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

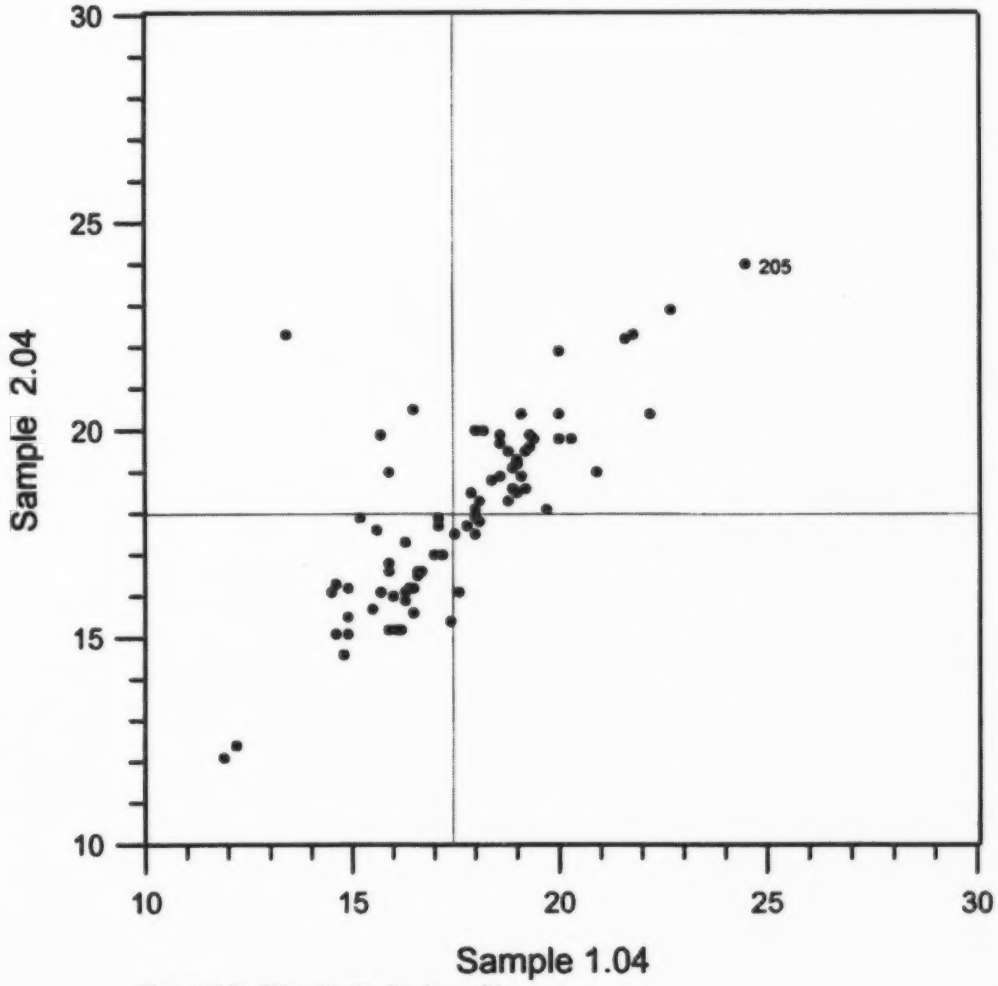


Test 47: Plastic Limit, %

	Mat 1	Mat 2
Mean	19.323	19.177
Median	19.000	18.800
Std Dev	1.378	1.407
n = 74		

Labs eliminated: 31, 100, 108

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

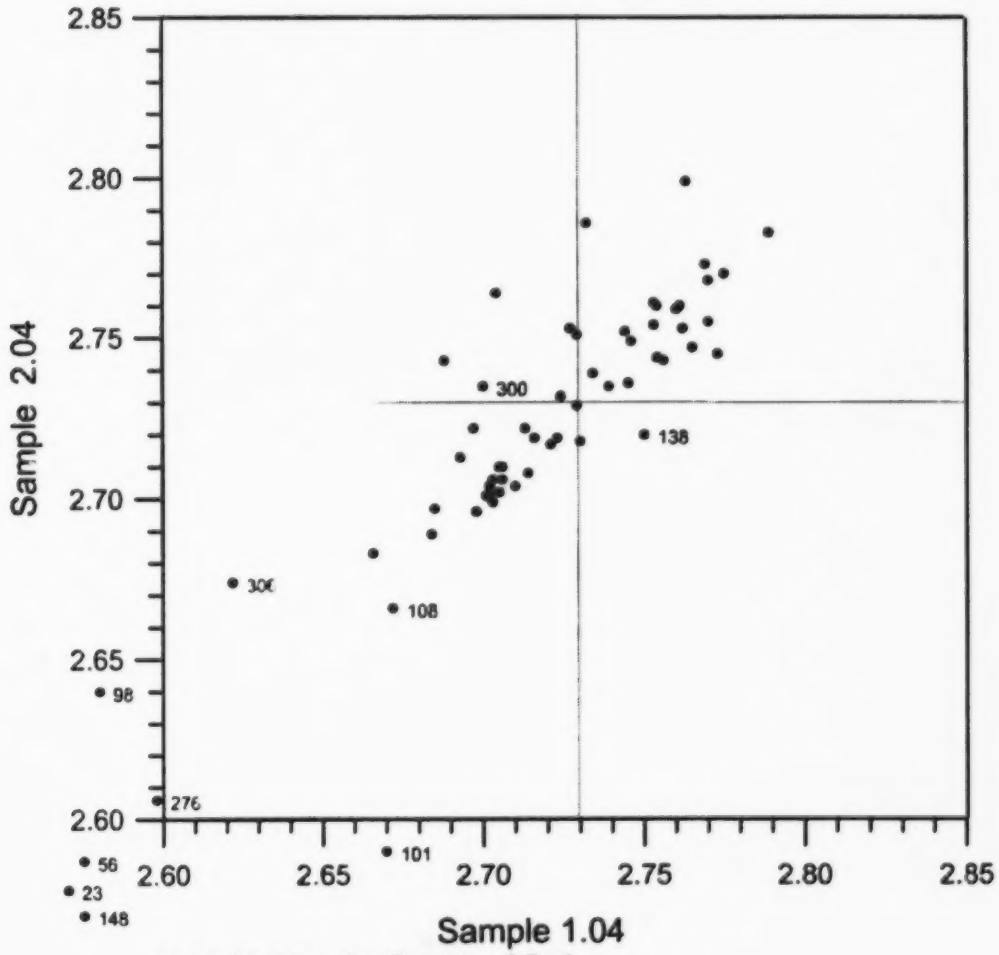


Test 48: Plasticity Index, %

	Mat 1	Mat 2
Mean	17.479	18.001
Median	17.300	17.500
Std Dev	2.148	2.272
n = 76		

Lab eliminated: 205

2004 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

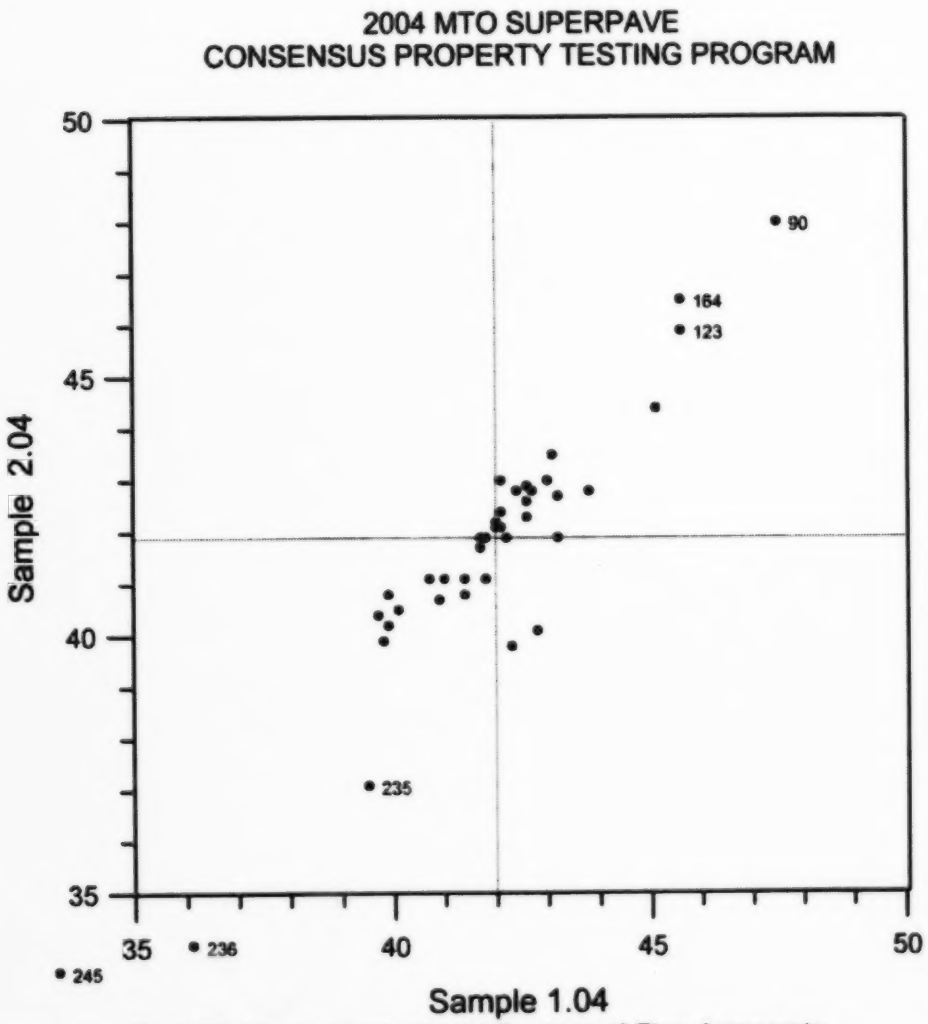


Test 49: Specific Gravity of Soil

	Mat 1	Mat 2
Mean	2.729	2.733
Median	2.728	2.741
Std Dev	0.029	0.029
n = 50		

Labs Eliminated: 23, 56, 98, 101, 108, 138, 148, 276, 300, 306

Appendix D2: Scatter Diagrams for Consensus Property Tests

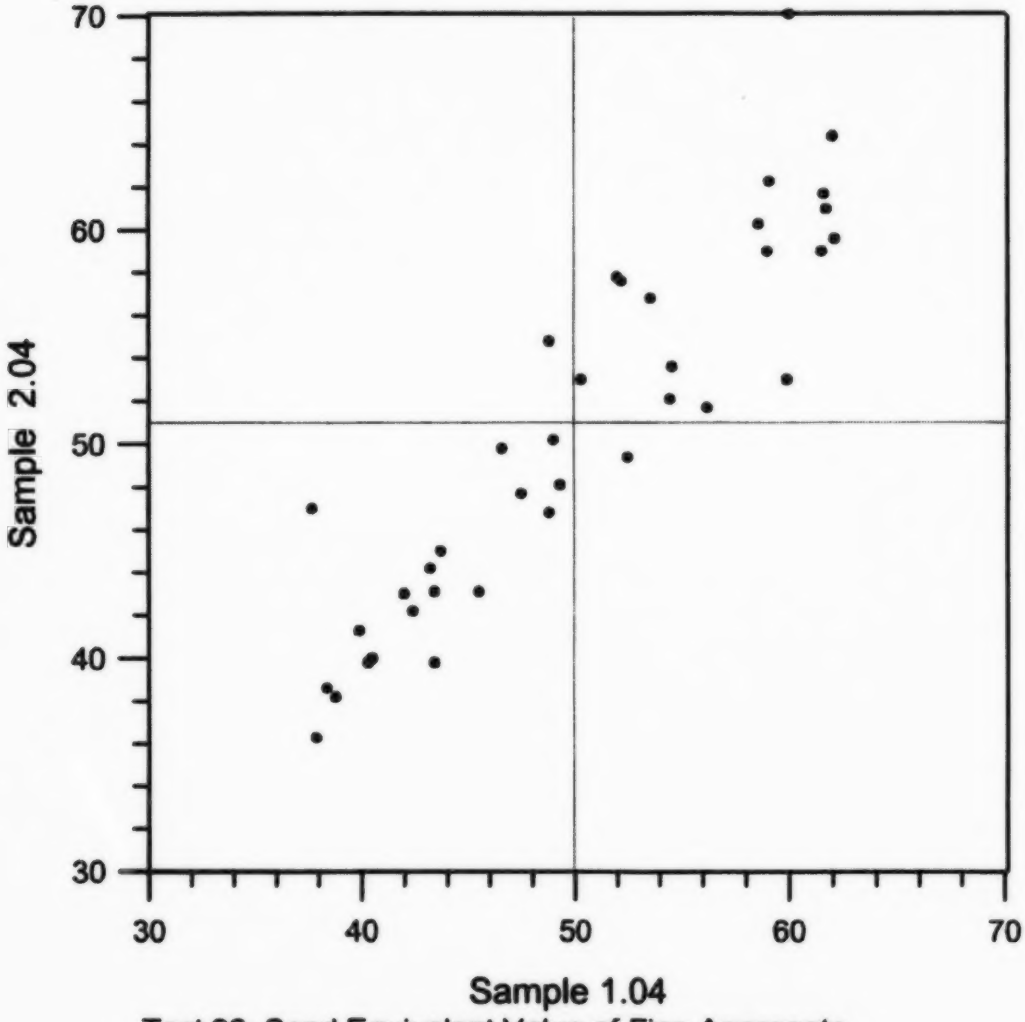


Test 95: Uncompacted Void Content of Fine Aggregate

	Mat 1	Mat 2
Mean	42.095	41.811
Median	42.400	42.100
Std Dev	1.481	1.112
n = 35		

Labs eliminated: 90, 123, 164, 235, 236, 245

2004 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM

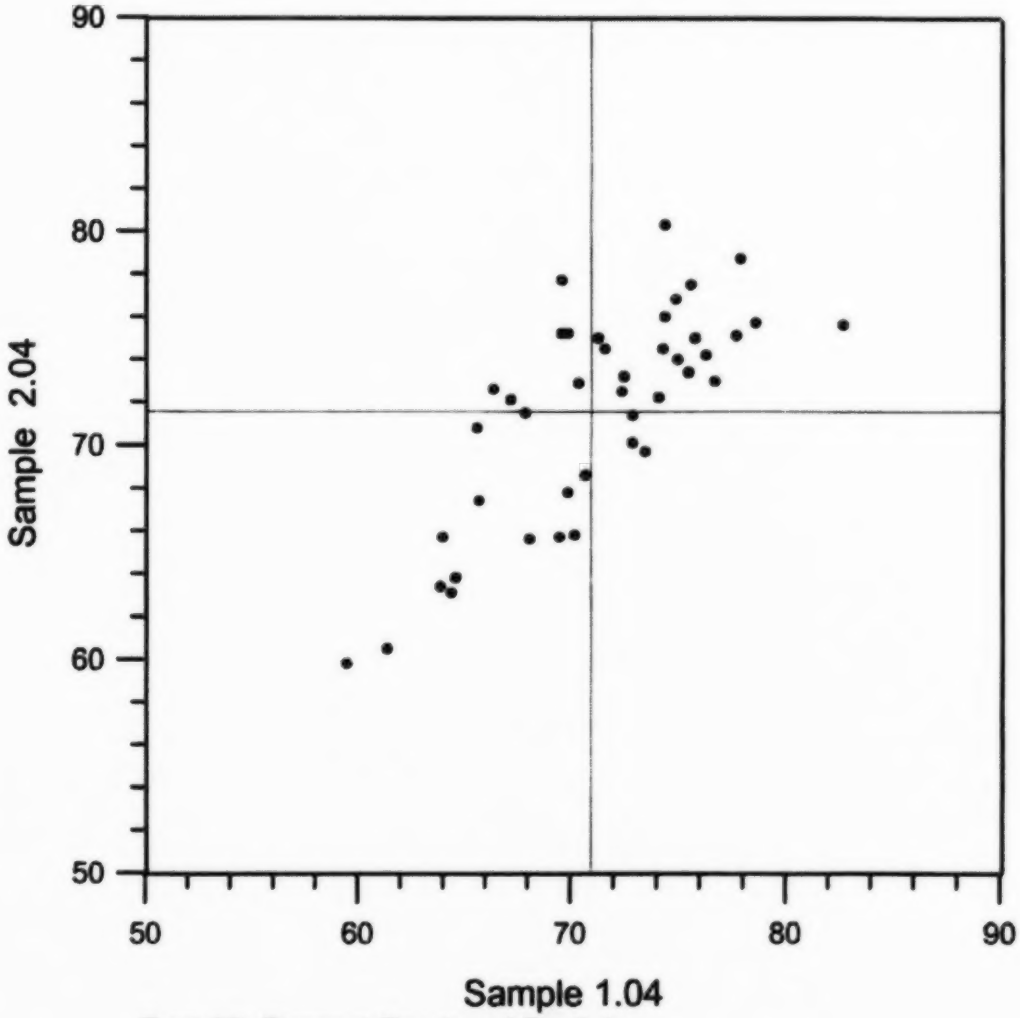


Test 96: Sand Equivalent Value of Fine Aggregate

	Mat 1	Mat 2
Mean	49.961	50.563
Median	49.900	53.200
Std Dev	8.086	8.586
n = 38		

Labs eliminated: None

2004 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM

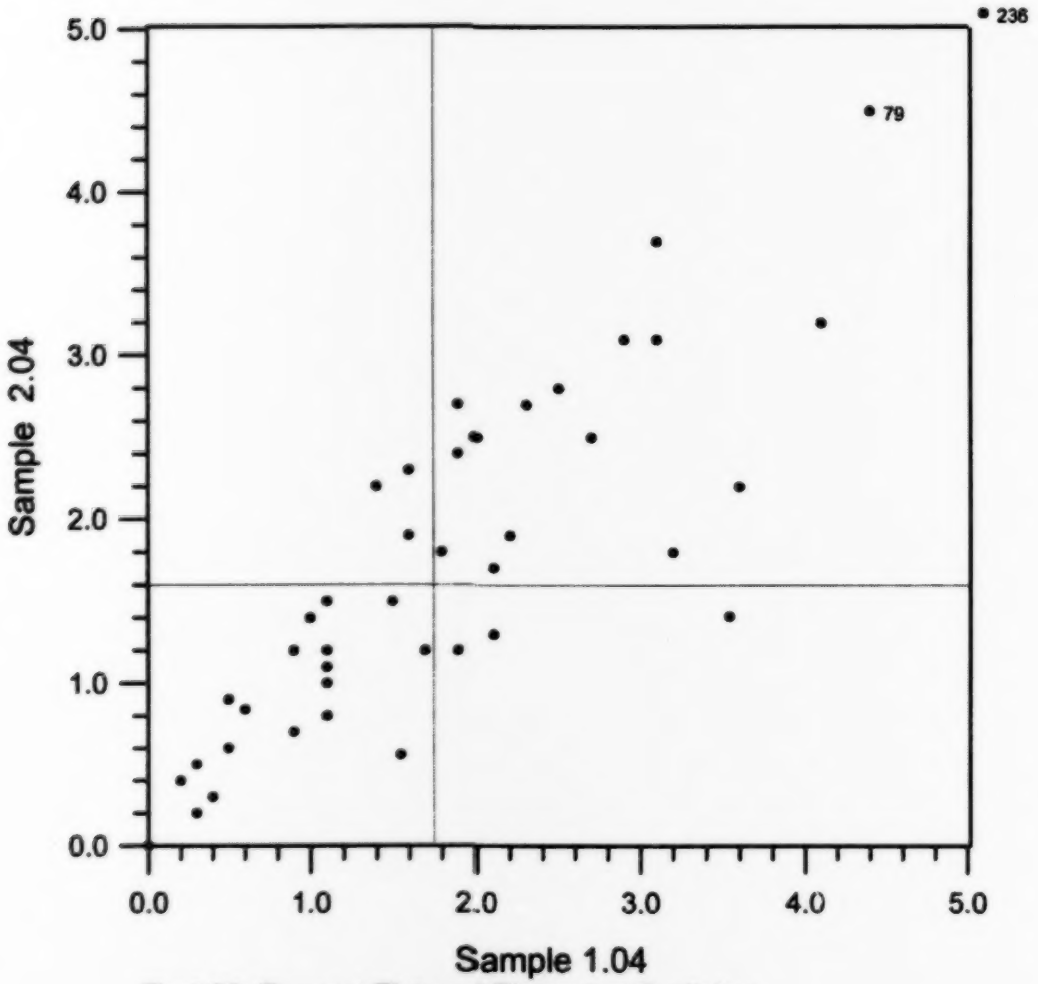


Test 97: Percent Fractured Particles

	Mat 1	Mat 2
Mean	71.179	71.514
Median	71.100	70.050
Std Dev	5.019	5.010
n = 42		

Labs Eliminated: None

2004 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



Test 99: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	1.751	1.608
Median	2.050	1.850
Std Dev	1.106	0.933
n = 40		

Labs Eliminated: 79, 236

Appendix E1: Results of Coarse Aggregate Petrographic Correlation

Laboratory Number	13	13	15	15	22	22	23	23	30	30
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	49.8	49.1	18.5	5	58.8	56.5	38.3	41.7	41.3	23.6
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	11.1	9.5	37.2	23.2	15.9	15.4	9.3	11.7	8.7	22.9
Carbonate (sandy, hard or medium hard)	0.8	1.7	4.3	24.4	0	0	5.3	9.5	22.4	9.1
Carbonate (slightly cherty: <5% chert)	4	1.5	1.6	10.8	0	0	1.7	3.1	0.2	2
Marble (hard or medium hard)	0	0.2	0	0	0	0	0	0	1.7	2.1
Conglomerate-Sandstone-Arkose (hard)	4.2	2.2	0.2	1.9	0	1.5	0	0	6.2	10.1
Conglomerate-Sandstone-Arkose (medium hard)	0	0	2.1	4.6	1.6	0	7.2	3	1.6	3.7
Greywacke-Argillite (hard or medium hard)	0	1.6	4.5	6.3	0	0	6.3	6.3	0	0
Gneiss-Amphibolite-Schist (hard)	0	0.2	0	0	0	0	0	0	0	0
Quartzite	0.2	0.7	0.7	0	2	4.7	0.5	1.2	1.3	0.3
Granite-Diorite-Gabbro (hard)	3.8	8	7	5.2	11.4	14.1	7.5	3.6	6.1	5.9
Volcanic (hard or medium hard)	2	1.3	0	2.2	0	0	0	0	0	0
Trap (<20% sulphide)	2.1	0.9	7.8	0	0	0	0.3	2.2	0	0
Quartz (vein or pegmatitic)	0	0	0.3	1	0	0	0	0	0	1.5
Sediment: Sibley Group (hard)	0	0	0	0	0	0	0	0	0	0
Flint/Jasper	0	0	0	0	0	0	0	0	0	3.9
Total Good Aggregate (%)	**78**	**76.9**	**84.2**	**84.6**	**89.7**	**92.2**	**76.4**	**82.3**	**89.5**	**85.1**
Carbonate (soft; silty, soft; slightly shaley)	7.1	7.3	1.8	1.8	2	1.6	4.8	3.9	0	0.2
Carbonate (soft, pitted)	0	0	2.4	8.6	0	0	4.5	4.1	4.9	2.4
Carbonate (deeply weath.; silty, deeply weath.)	0.2	1	3.8	0	1.6	0	0	0	0	0
Carbonate (sandy, soft)	0.4	0	0.3	0	0	0	9.1	5.3	0	0
Chert-Cherty Carbonate (<20% leached chert)	8.9	8.9	2.2	0	5.3	2.9	1.2	0	3.1	7.2
Conglomerate-Sandstone-Arkose (brittle)	0	0	0	0	0	1.1	1.3	1.2	1.2	4.8
Encrustation	0	0	0	0	0	0	0.6	0.2	0	0
Gneiss-Amphibolite-Schist (brittle)	0	0	0	0	0.4	0	0	0	0.4	0
Argillite (medium soft)	0	0	0	0	0	0	0	0	0	0
Granite-Diorite-Gabbro (brittle)	0	0	0.6	0.8	0.7	0.2	0.3	0.5	0	0.3
Total Fair Aggregate (%)	**16.6**	**17.2**	**11.1**	**11.2**	**10**	**5.8**	**21.8**	**15.2**	**9.6**	**14.9**
Carbonate (shaley; clayey; silty, clayey)	0.5	0.7	1.1	4	0	0	0.3	0.6	0	0
Carbonate (ochreous; sandy, ochreous)	0	0	0.5	0	0	0	0	0	0	0
Chert-Cherty Carbonate (>20% leached chert)	4.3	4.9	0.4	0	0.3	2	0	1.3	0.9	0
Conglomerate-Sandstone-Arkose (friable)	0	0	0.4	0	0	0	1.3	0.6	0	0
Siltstone	0	0	1.8	0	0	0	0	0	0	0
Cementation (partial)	0	0	0	0	0	0	0	0	0	0
Cementation (total)	0.4	0	0	0	0	0	0.1	0	0	0
Schist (soft)	0	0	0.3	0	0	0	0	0	0	0
Granite-Diorite-Gabbro (friable)	0	0	0	0	0	0	0	0	0	0
Total Poor Aggregate (%)	**5.2**	**5.6**	**4.5**	**4**	**0.3**	**2**	**1.7**	**2.5**	**0.9**	**0**
Ochre	0	0	0.2	0.2	0	0	0	0	0	0
Shale	0.2	0	0	0	0	0	0.1	0	0	0
Clay	0	0.3	0	0	0	0	0	0	0	0
Volcanic-Gneiss-Schist (decomposed)	0	0	0	0	0	0	0	0	0	0
Total Deleterious Aggregate (%)	**0.2**	**0.3**	**0.2**	**0.2**	**0**	**0**	**0.1**	**0**	**0**	**0**
Petrographic Number (Concrete)	**161**	**165**	**146**	**144**	**122**	**122**	**153**	**143**	**124**	**130**

Laboratory Number	**31**	**31**	**35**	**35**	**37**	**37**	**38**	**38**	**39**	**39**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	73.5	74	59.4	64.8	33.6	58.6	0	0	47	50.7
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	0	0	8.1	7	30.8	14.2	75.4	71.4	1.2	1
Carbonate (sandy, hard or medium hard)	0	0	0	0	1.1	0	2.5	0	15	14.3
Carbonate (slightly cherty: <5% chert)	0	0	0	0	5.4	2.3	0	0	0	0
Marble (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Conglomerate-Sandstone-Arkose (hard)	5	3.4	5.9	2.6	0.5	1.4	0	0	1.8	1.4
Conglomerate-Sandstone-Arkose (medium hard)	0	0	0	0	0.4	0	0	0	0	0
Greywacke-Argillite (hard or medium hard)	0	0	0	0	0.3	2.6	0	0	0	0
Gneiss-Amphibolite-Schist (hard)	0	0	2.1	4.5	0.3	0	11	4.5	0	0
Quartzite	0	0	0	0	0.1	0.7	0	0	1.1	0.9
Granite-Diorite-Gabbro (hard)	8	5.4	3.3	1	10	5.5	0	0	10.6	9
Volcanic (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Trap (<20% sulphide)	0	0	0	0	0	0	0	0	0	0
Quartz (vein or pegmatitic)	0	0	0	0	0	0	0	0	0	0
Sediment: Sibley Group (hard)	0	0	0	0	0.4	0	0	0	0	0
Flint/Jasper	0	0	0	0	0	0	0	0	0	0
Total Good Aggregate (%)	**86.5**	**82.8**	**78.8**	**79.9**	**82.9**	**85.3**	**88.9**	**75.9**	**76.7**	**77.3**
Carbonate (soft; silty, soft; slightly shaley)	3.9	1.2	8.2	9.2	10.3	5	0	0	11.3	9.5
Carbonate (soft, pitted)	0	0	0	0	0.2	0.7	8.5	6.2	8	8.8
Carbonate (deeply weath.; silty, deeply weath.)	0	0	0	0	1.5	0.2	0	0	0	0
Carbonate (sandy, soft)	0	0	0	0	0	0	0	0	0	0
Chert-Cherty Carbonate (<20% leached chert)	4.7	14.4	8.6	6.9	0	4.2	1.1	12.9	2.1	1.8
Conglomerate-Sandstone-Arkose (brittle)	0	0	0	0	0	0.3	0	0	0	0
Encrustation	0	0	0	0	0	0	0	0	1	1.2
Gneiss-Amphibolite-Schist (brittle)	0	0	0	0	0	0	0.6	0.7	0.4	0.8
Argillite (medium soft)	0	0	0	0	0	0	0	0	0	0
Granite-Diorite-Gabbro (brittle)	0	0	0	0	0.3	0.2	0	0	0	0
Total Fair Aggregate (%)	**8.6**	**15.6**	**16.8**	**16.1**	**12.3**	**10.6**	**10.2**	**19.8**	**22.8**	**22.1**
Carbonate (shaley; clayey; silty, clayey)	0.8	0.4	2.3	2.1	3.5	1.1	0	0	0	0
Carbonate (ochreous; sandy, ochreous)	0	0	0	0	0	0	0	0	0	0.4
Chert-Cherty Carbonate (>20% leached chert)	4.1	1.2	2.1	0.8	1.2	1.4	0.9	4.3	0	0
Conglomerate-Sandstone-Arkose (friable)	0	0	0	0	0	0	0	0	0	0
Siltstone	0	0	0	0	0.1	0.4	0	0	0	0
Cementation (partial)	0	0	0	0.4	0	0	0	0	0	0
Cementation (total)	0	0	0	0.4	0	0.9	0	0	0	0
Schist (soft)	0	0	0	0	0	0	0	0	0	0
Granite-Diorite-Gabbro (friable)	0	0	0	0	0	0.2	0	0	0.5	0.2
Total Poor Aggregate (%)	**4.9**	**1.6**	**4.4**	**3.7**	**4.8**	**4**	**0.9**	**4.3**	**0.5**	**0.6**
Ochre	0	0	0	0	0	0	0	0	0	0
Shale	0	0	0	0	0	0	0	0	0	0
Clay	0	0	0	0.3	0	0.1	0	0	0	0
Volcanic-Gneiss-Schist (decomposed)	0	0	0	0	0	0	0	0	0	0
Total Deleterious Aggregate (%)	**0**	**0**	**0**	**0.3**	**0**	**0.1**	**0**	**0**	**0**	**0**
Petrographic Number (Concrete)	**142**	**139**	**155**	**153**	**149**	**142**	**125**	**161**	**149**	**145**

Laboratory Number	**47**	**47**	**59**	**59**	**61**	**61**	**71**	**71**	**80**	**80**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	61	57.8	46.1	38.8	56	53.7	66.7	51.9	50.2	54.6
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	8	14.4	9.3	11.1	0	0	14.9	0	8.7	9
Carbonate (sandy, hard or medium hard)	0	0	0.2	0	7.9	9.4	2	13.2	0	3.2
Carbonate (slightly cherty: <5% chert)	0	0	3.2	3.4	4.6	3.3	1	0	1.5	1.6
Marble (hard or medium hard)	0	0	0.3	0	0	0	0	0	3	0
Conglomerate-Sandstone-Arkose (hard)	5.3	2.2	2.1	6.6	10.4	12.4	3.4	5.5	6	2.9
Conglomerate-Sandstone-Arkose (medium hard)	0	0	0	0.5	0	0	0	0	0	0
Greywacke-Argillite (hard or medium hard)	0	2	4.9	0.9	4.8	3.6	0	0	0	0.6
Gneiss-Amphibolite-Schist (hard)	1.4	0	0.9	1.6	0	0	0	0	0.1	0
Quartzite	0	2.4	1.1	0.9	1.1	1.6	1.5	0	0.4	0.9
Granite-Diorite-Gabbro (hard)	6.7	4.9	6	3	3.7	3.8	1	6.4	5.6	5.8
Volcanic (hard or medium hard)	0	0	0.6	0	0.8	0	0	0	0	0
Trap (<20% sulphide)	0	0	0	0	0	0	0	0	2.1	1.2
Quartz (vein or pegmatitic)	0	0	0	0	0.2	0	0	0	0	0
Sediment: Sibley Group (hard)	0	0	0	0	0	0	0	0	0	0
Flint/Jasper	0	0	0	0	0	0	0	0	0	0
Total Good Aggregate (%)	**82.4**	**83.7**	**74.7**	**66.8**	**89.5**	**87.8**	**90.5**	**77**	**77.6**	**79.8**
Carbonate (soft; silty, soft; slightly shaley)	5.2	5.9	13.7	16.8	2.4	2.4	0	0	0	5.8
Carbonate (soft, pitted)	0	0	0	0	2.8	3.1	0.5	0	5.7	0
Carbonate (deeply weath.; silty, deeply weath.)	0	1.7	1.3	0.1	0	0	0	0	0.9	0
Carbonate (sandy, soft)	0	0	0	0	0	0.9	0	0.9	0	1.4
Chert-Cherty Carbonate (<20% leached chert)	8.2	5.9	8.3	13.7	1.4	0.6	2.5	3.7	10.4	8.7
Conglomerate-Sandstone-Arkose (brittle)	0	0	0	0	0	0	1.3	1.8	0	0
Encrustation	0	0	0	0	0.6	0.8	0	0	0	0.9
Gneiss-Amphibolite-Schist (brittle)	0	0.1	0	0	0.5	0.7	1.2	0	0	0
Argillite (medium soft)	0	0	0	0	0	0	0	0	0	0
Granite-Diorite-Gabbro (brittle)	0	0	0	0	0	0	1	0	0	0
Total Fair Aggregate (%)	**13.4**	**13.6**	**23.3**	**30.6**	**7.7**	**8.5**	**6.5**	**6.4**	**17**	**16.8**
Carbonate (shaley; clayey; silty, clayey)	2.1	0.3	0.8	0.8	1.7	2.1	0	2.1	0.8	0.7
Carbonate (ochreous; sandy, ochreous)	0	0	0.1	0.1	0	0	0	0.9	0	0
Chert-Cherty Carbonate (>20% leached chert)	1.7	2	1.1	1.7	0	0	1	5.5	4	2.4
Conglomerate-Sandstone-Arkose (friable)	0	0	0	0	1.1	1.6	1	0	0	0
Siltstone	0	0	0	0	0	0	0	3.6	0	0
Cementation (partial)	0	0	0	0	0	0	0	0	0	0.3
Cementation (total)	0	0	0	0	0	0	0	0	0	0
Schist (soft)	0	0	0	0	0	0	0	0	0	0
Granite-Diorite-Gabbro (friable)	0	0	0	0	0	0	1	4.5	0	0
Total Poor Aggregate (%)	**3.8**	**2.3**	**2**	**2.6**	**2.8**	**3.7**	**3**	**16.6**	**4.8**	**3.4**
Ochre	0.4	0	0	0	0	0	0	0	0	0
Shale	0	0	0	0	0	0	0	0	0	0
Clay	0	0.4	0	0	0	0	0	0	0.6	0
Volcanic-Gneiss-Schist (decomposed)	0	0	0	0	0	0	0	0	0	0
Total Deleterious Aggregate (%)	**0.4**	**0.4**	**0**	**0**	**0**	**0**	**0**	**0**	**0.6**	**0**
Petrographic Number (Concrete)	**149**	**142**	**157**	**174**	**129**	**136**	**128**	**196**	**163**	**151**

Laboratory Number	**83**	**83**	**100**	**100**	**101**	**101**	**112**	**112**	**150**	**150**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	39.9	25.8	45.9	47	66.5	70.5	69.6	75.6	50.2	45.1
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	11.3	33.9	16.4	13.3	1.4	0	15.5	7.9	12.4	7.4
Carbonate (sandy, hard or medium hard)	12.6	2.7	3.2	4.2	0.2	0	0	0	0	0
Carbonate (slightly cherty: <5% chert)	0	0	0.1	1	1.9	2.1	0	0	2.2	3.3
Marble (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Conglomerate-Sandstone-Arkose (hard)	2.3	2.5	2.8	3.3	0.3	1	0	0	1.8	3.7
Conglomerate-Sandstone-Arkose (medium hard)	0.9	4.4	0	0	0	0	0.1	0	0	0
Greywacke-Argillite (hard or medium hard)	4.3	7.5	1.6	2.2	4.6	3.1	0	0	3.7	4.2
Gneiss-Amphibolite-Schist (hard)	1.1	0	0	0	0.9	0.6	0	0	0	0
Quartzite	1.7	0	0.7	0.2	2.8	1.1	0	0	0	0
Granite-Diorite-Gabbro (hard)	0	0	7.8	9.9	4.4	1.7	9.8	9	3.1	7
Volcanic (hard or medium hard)	0	0	0.3	0	1.6	0.3	0	0	0	0
Trap (<20% sulphide)	0	0	0	0	0.8	0.6	0	0	0	0
Quartz (vein or pegmatitic)	0	0	0	0	0	0	0	0	0	0
Sediment: Sibley Group (hard)	0	0	0	0	0	0	0	0	0	0
Flint/Jasper	0	0	0	0	0	0	0	0	0	0
Total Good Aggregate (%)	**74.1**	**76.8**	**78.8**	**81.1**	**85.4**	**81**	**95**	**92.5**	**73.4**	**70.7**
Carbonate (soft; silty, soft; slightly shaley)	11.9	7.6	5.8	4.9	0.9	1.9	0.3	0.5	10.3	5.5
Carbonate (soft, pitted)	6.2	8.1	1.8	2	0	0	2.5	5.7	0	0.4
Carbonate (deeply weath.; silty, deeply weath.)	0	1.4	1.2	2	0	0	1.3	0	0	1.2
Carbonate (sandy, soft)	0	0	0.9	0.1	0	0	0	0	0	0.6
Chert-Cherty Carbonate (<20% leached chert)	5.5	3.5	7.5	5.8	9.8	12.9	0	0	15.2	21.1
Conglomerate-Sandstone-Arkose (brittle)	1.2	0	0	0	0	0	0	0	0	0
Encrustation	0	0	0.3	0	0	0.7	0	0	0	0
Gneiss-Amphibolite-Schist (brittle)	0.5	0	0	0	0	0	0	0	0	0
Argillite (medium soft)	0	0	0	0	0	0	0	0	0.4	0
Granite-Diorite-Gabbro (brittle)	0	0	0	0	0	0	0.4	0.5	0	0
Total Fair Aggregate (%)	**25.3**	**20.6**	**17.5**	**14.8**	**10.7**	**15.5**	**4.5**	**6.7**	**25.9**	**28.8**
Carbonate (shaley; clayey; silty, clayey)	0	2.6	1.2	1.1	0.2	0.4	0.5	0.7	0	0.5
Carbonate (ochreous; sandy, ochreous)	0	0	0	0	0	0	0	0	0	0
Chert-Cherty Carbonate (>20% leached chert)	0	0	2.3	2.3	3.7	3.1	0	0	0	0
Conglomerate-Sandstone-Arkose (friable)	0	0	0	0	0	0	0	0	0	0
Siltstone	0.6	0	0	0	0	0	0	0	0	0
Cementation (partial)	0	0	0.1	0.2	0	0	0	0	0	0
Cementation (total)	0	0	0	0.2	0	0	0	0.1	0	0
Schist (soft)	0	0	0	0	0	0	0	0	0	0
Granite-Diorite-Gabbro (friable)	0	0	0	0	0	0	0	0	0.7	0
Total Poor Aggregate (%)	**0.6**	**2.6**	**3.6**	**3.8**	**3.9**	**3.5**	**0.5**	**0.8**	**0.7**	**0.5**
Ochre	0	0	0.1	0.2	0	0	0	0	0	0
Shale	0	0	0	0	0	0	0	0	0	0
Clay	0	0	0	0.1	0	0	0	0	0	0
Volcanic-Gneiss-Schist (decomposed)	0	0	0	0	0	0	0	0	0	0
Total Deleterious Aggregate (%)	**0**	**0**	**0.1**	**0.3**	**0**	**0**	**0**	**0**	**0**	**0**
Petrographic Number (Concrete)	**154**	**154**	**154**	**151**	**141**	**149**	**111**	**117**	**155**	**160**

Laboratory Number	**172**	**172**	**188**	**188**	**196**	**196**	**260**	**260**	**295**	**295**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	8.6	7.6	3.5	6.6	49.6	49.7	45.4	61	7.9	4.6
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	58.2	62.6	59.6	60.2	11.1	9.6	23.3	13.6	68.8	60.7
Carbonate (sandy, hard or medium hard)	0	0	1.1	0.7	0.8	1.7	1	0	0	0
Carbonate (slightly cherty: <5% chert)	2.7	2.6	1.5	0.6	3.8	1.5	0	0	0.1	2.9
Marble (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Conglomerate-Sandstone-Arkose (hard)	0	0	5.4	3.1	4.1	2.3	1	1.8	0	0
Conglomerate-Sandstone-Arkose (medium hard)	0.2	0	0	0	0	0	0.4	0	1.1	1.6
Greywacke-Argillite (hard or medium hard)	0	0.3	0.8	1.1	0	1.6	1.8	0.6	0.6	1.4
Gneiss-Amphibolite-Schist (hard)	0	0	1	1	0	0.3	0.5	0	0	0
Quartzite	0	0.5	0.4	1.1	0.2	0.8	0	0.4	0	0
Granite-Diorite-Gabbro (hard)	4.5	5.4	5.3	3.7	3.8	7.6	1.5	6.5	4.9	2.4
Volcanic (hard or medium hard)	0	0	0	0	2	1.2	0	0	2.9	5.5
Trap (<20% sulphide)	2	3.6	0	0.8	2.1	1	2.1	3.7	0	0
Quartz (vein or pegmatitic)	0	0	0	0	0	0	0	0	0	0
Sediment: Sibley Group (hard)	0	0	0	0	0	0	0	0	0	0
Flint/Jasper	0	0	0	0	0	0	0	0	0	0
Total Good Aggregate (%)	**76.2**	**82.6**	**78.6**	**78.9**	**77.5**	**77.3**	**77**	**87.6**	**86.3**	**79.1**
Carbonate (soft; silty, soft; slightly shaley)	21.3	15	7.6	6.8	5.7	7.5	0	0	4.6	7.9
Carbonate (soft, pitted)	0	0	0	0	1	0	0	0	0	0
Carbonate (deeply weath.; silty, deeply weath.)	0	0	2.9	1.8	0	0.9	0	0	0	0
Carbonate (sandy, soft)	0	0	0.4	0	0	0	10.6	5	0	0
Chert-Cherty Carbonate (<20% leached chert)	0	0	5.4	6.9	10.4	8.6	8.2	5.5	5.1	7.1
Conglomerate-Sandstone-Arkose (brittle)	0	0	1.1	0.5	0	0	0	0	0	0
Encrustation	0	0	0	0	0	0	0	0.9	0	0
Gneiss-Amphibolite-Schist (brittle)	0	0	0	0	0	0	0	0	0	0
Argillite (medium soft)	0	0	0	0.8	0	0	0	0	0	0
Granite-Diorite-Gabbro (brittle)	0	0	0.4	0.6	0	0	0	0	0	0.3
Total Fair Aggregate (%)	**21.3**	**15**	**17.8**	**17.4**	**17.1**	**17**	**18.8**	**11.4**	**9.7**	**15.3**
Carbonate (shaley; clayey; silty, clayey)	2.5	0	1.8	2.7	0.8	0.7	0	0	0	0
Carbonate (ochreous; sandy, ochreous)	0	2.1	0	0	0	0	0.5	0	0	0
Chert-Cherty Carbonate (>20% leached chert)	0	0.3	1.2	1	4.1	4.7	3.7	1	3.2	5.1
Conglomerate-Sandstone-Arkose (friable)	0	0	0	0	0	0	0	0	0	0
Siltstone	0	0	0	0	0	0	0	0	0	0
Cementation (partial)	0	0	0	0	0	0	0	0	0	0
Cementation (total)	0	0	0.6	0	0	0	0	0	0	0
Schist (soft)	0	0	0	0	0	0	0	0	0	0
Granite-Diorite-Gabbro (friable)	0	0	0	0	0	0	0	0	0.2	0
Total Poor Aggregate (%)	**2.5**	**2.4**	**3.6**	**3.7**	**4.9**	**5.4**	**4.2**	**1**	**3.4**	**5.1**
Ochre	0	0	0	0	0	0	0	0	0	0
Shale	0	0	0	0	0	0	0	0	0.3	0
Clay	0	0	0	0	0.5	0.3	0	0	0	0.5
Volcanic-Gneiss-Schist (decomposed)	0	0	0	0	0	0	0	0	0.3	0
Total Deleterious Aggregate (%)	**0**	**0**	**0**	**0**	**0.5**	**0.3**	**0**	**0**	**0.6**	**0.5**
Petrographic Number (Concrete)	**155**	**142**	**154**	**153**	**163**	**164**	**159**	**128**	**142**	**161**

Appendix E2: Results of Fine Aggregate Petrographic Correlation

Laboratory Number	35	35	37	37	47	47	59	59	80	80	101	101
Sample Number	1	2	1	2	1	2	1	2	1	2	1	2
Silicate (4.75-2.36 mm)	40.2	27.8	79.5	52.5	31.5	34.5	36.5	31	35	32.5	37.6	32.7
Silicate (2.36-1.18 mm)	46.9	48.9	78.5	60	32	31.5	30.5	28	44.5	35	34	29.8
Silicate (1.18-0.600 mm)	48.5	59.7	81	57	29	35	51	43.5	57	45	47.2	37.3
Silicate (0.600-0.300 mm)	61.9	58	87	64	53	60.5	58	62	64	59	52.4	63.1
Silicate (0.300-0.150 mm)	74.4	70.7	93	72	58	73.5	73.5	74.5	69	64	75.5	74.4
Silicate (0.150-0.075 mm)	70.1	71.4	89	69	64	70	76.5	78	71	71	79.7	72.4
Silicate (average) (%)	**57**	**56.1**	**84.7**	**62.4**	**44.6**	**50.9**	**54.3**	**52.8**	**56.8**	**51.1**	**54.4**	**51.6**
Carbonate (4.75-2.36 mm)	50	63.5	14	39.5	43.5	46.5	48	44.5	57.5	58	47.6	48.3
Carbonate (2.36-1.18 mm)	37.8	40.7	12	28.5	44.5	46.5	46	44.5	37.5	47.5	45.1	54
Carbonate (1.18-0.600 mm)	34.8	26.3	10	31	52.5	51.5	30.5	37	32	41	46.3	41.8
Carbonate (0.600-0.300 mm)	32.1	31.4	4.5	27	38	34	32	24.5	26.5	29.5	31.1	28.7
Carbonate (0.300-0.150 mm)	22.3	21.5	3	18	40	22	24.5	22.5	24	24	22.6	20.9
Carbonate (0.150-0.075 mm)	19.8	18.1	1	18	33	28	21	17.5	21.5	22	16.8	23.7
Carbonate (average) (%)	**32.8**	**33.6**	**7.4**	**27**	**41.9**	**38.1**	**33.7**	**31.8**	**33.2**	**37**	**34.9**	**36.2**
Shale (4.75-2.36 mm)	5.1	1.8	6	5	11.5	7	5	13	3	7.5	2.4	8.1
Shale (2.36-1.18 mm)	11.7	8.2	3.5	9.5	16	12	14.5	14	16.5	15	10.2	11.8
Shale (1.18-0.600 mm)	15.4	12.7	2.5	10.5	15.5	6.5	12.5	12	9.5	12.5	3.5	16.9
Shale (0.600-0.300 mm)	5.6	10.2	5.5	9	7.5	4	7	9.5	9	11.5	14.6	5.8
Shale (0.300-0.150 mm)	2.5	5.1	2.5	9	1.5	3	2	2.5	7	12	1.4	3.8
Shale (0.150-0.075 mm)	3.5	2.1	0.5	13	1	0	0.5	1.5	7.5	5.5	2	2.9
Shale (average) (%)	**7.3**	**6.7**	**3.4**	**9.3**	**8.8**	**5.4**	**6.9**	**8.7**	**8.7**	**10.7**	**5.7**	**8.2**
Mica (4.75-2.36 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Mica (2.36-1.18 mm)	0	0	1.5	0	0	0	0	0	0	0	0	0
Mica (1.18-0.600 mm)	0	0	0.5	0	0	0	0	0	0	0	0	0
Mica (0.600-0.300 mm)	0	0	1	0	0	0	0	0	0	0	0	0
Mica (0.300-0.150 mm)	0.8	2.7	1	0.5	0.5	0	0	0.5	0	0	0	0
Mica (0.150-0.075 mm)	6.6	8.4	9	0	2	2	2	3	0	1.5	1.5	0.5
Mica (average) (%)	**1.2**	**1.8**	**2.2**	**0.1**	**0.4**	**0.3**	**0.3**	**0.6**	**0**	**0.2**	**0.3**	**0.1**
Chert (4.75-2.36 mm)	4.7	5.2	0	1.5	13.5	12	10.5	11.5	4.5	2	12.4	10.9
Chert (2.36-1.18 mm)	3.6	2.2	0	1.5	7.5	10	9	13.5	1.5	2.5	10.7	4.6
Chert (1.18-0.600 mm)	1.3	1.3	0	1	3	7	6	7.5	1.5	1.5	3	4
Chert (0.600-0.300 mm)	0.4	0.4	0	0	1.5	1.5	3	4	0.5	0	1.9	2.4
Chert (0.300-0.150 mm)	0	0	0	0.5	0	1.5	0	0	0	0	0.5	0.9
Chert (0.150-0.075 mm)	0	0	0	0	0	0	0	0	0	0	0	0.5
Chert (average) (%)	**1.7**	**1.5**	**0**	**0.8**	**4.3**	**5.3**	**4.8**	**6.1**	**1.3**	**1**	**4.7**	**3.9**
Contamination (4.75-2.36 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (2.36-1.18 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (1.18-0.600 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (0.600-0.300 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (0.300-0.150 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (0.150-0.075 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (average) (%)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cementation (4.75-2.36 mm)	0	1.7	0.5	1.5	0	0	0	0	0	0	0	0
Cementation (2.36-1.18 mm)	0	0	4.5	0.5	0	0	0	0	0	0	0	0
Cementation (1.18-0.600 mm)	0	0	6	0.5	0	0	0	0	0	0	0	0
Cementation (0.600-0.300 mm)	0	0	2	0	0	0	0	0	0	0	0	0
Cementation (0.300-0.150 mm)	0	0	0.5	0	0	0	0	0	0	0	0	0
Cementation (0.150-0.075 mm)	0	0	0.5	0	0	0	0	0	0	0	0	0
Cementation (average) (%)	**0**	**0.3**	**2.3**	**0.4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Laboratory Number	**150**	**150**	**188**	**188**	**196**	**196**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**
Silicate (4.75-2.36 mm)	48.5	47.8	46.5	46	36.5	31.5
Silicate (2.36-1.18 mm)	49.3	48.2	55.5	50.5	45.5	34.5
Silicate (1.18-0.600 mm)	58.2	57.3	61	64	56	45.5
Silicate (0.600-0.300 mm)	64.5	64.3	78.5	72	62	58
Silicate (0.300-0.150 mm)	70.1	71.6	88	85.5	68	63
Silicate (0.150-0.075 mm)	70.5	72.4	94	93.5	70.5	70
Silicate (average) (%)	**60.2**	**60.3**	**70.6**	**68.6**	**56.4**	**50.4**
Carbonate (4.75-2.36 mm)	38.9	34.3	42	40.5	56	57
Carbonate (2.36-1.18 mm)	29.3	30	32	33	37.5	46
Carbonate (1.18-0.600 mm)	27.9	27.1	27.5	23	33	40.5
Carbonate (0.600-0.300 mm)	27.4	27.6	14	18	28.5	30
Carbonate (0.300-0.150 mm)	25.2	25.9	6	7	22.5	24
Carbonate (0.150-0.075 mm)	19.5	20.5	2.5	2.5	20.5	20
Carbonate (average) (%)	**28**	**27.6**	**20.7**	**20.6**	**33**	**36.3**
Shale (4.75-2.36 mm)	4.2	6.1	3	4.5	4	9.5
Shale (2.36-1.18 mm)	14.5	13.6	7	9	15.5	16
Shale (1.18-0.600 mm)	9.7	11.9	7.5	8	10	12
Shale (0.600-0.300 mm)	7.4	7	3.5	6	8.5	12
Shale (0.300-0.150 mm)	4.2	2.5	1.5	3	9.5	12.5
Shale (0.150-0.075 mm)	6.5	3.3	0	0	9	9
Shale (average) (%)	**7.7**	**7.4**	**3.7**	**5.1**	**9.4**	**11.8**
Mica (4.75-2.36 mm)	0	0	0	0	0	0
Mica (2.36-1.18 mm)	0	0	0	0	0	0
Mica (1.18-0.600 mm)	0	0	0	0	0	0
Mica (0.600-0.300 mm)	0	0	0	0	0	0
Mica (0.300-0.150 mm)	0.5	0	2	2.5	0	0
Mica (0.150-0.075 mm)	3.5	3.3	3.5	4	0	1
Mica (average) (%)	**0.7**	**0.5**	**0.9**	**1.1**	**0**	**0.2**
Chert (4.75-2.36 mm)	8.4	11.8	7.5	8	3.5	2
Chert (2.36-1.18 mm)	6.9	8.2	5.5	7.5	1.5	3.5
Chert (1.18-0.600 mm)	4.2	3.7	4	5	1	2
Chert (0.600-0.300 mm)	0.7	1.1	4	4	1	0
Chert (0.300-0.150 mm)	0	0	2.5	2	0	0.5
Chert (0.150-0.075 mm)	0	0.5	0	0	0	0
Chert (average) (%)	**3.4**	**4.2**	**3.9**	**4.4**	**1.2**	**1.3**
Contamination (4.75-2.36 mm)	0	0	0	0	0	0
Contamination (2.36-1.18 mm)	0	0	0	0	0	0
Contamination (1.18-0.600 mm)	0	0	0	0	0	0
Contamination (0.600-0.300 mm)	0	0	0	0	0	0
Contamination (0.300-0.150 mm)	0	0	0	0	0	0
Contamination (0.150-0.075 mm)	0	0	0	0	0	0
Contamination (average) (%)	**0**	**0**	**0**	**0**	**0**	**0**
Cementation (4.75-2.36 mm)	0	0	1	1	0	0
Cementation (2.36-1.18 mm)	0	0	0	0	0	0
Cementation (1.18-0.600 mm)	0	0	0	0	0	0
Cementation (0.600-0.300 mm)	0	0	0	0	0	0
Cementation (0.300-0.150 mm)	0	0	0	0	0	0
Cementation (0.150-0.075 mm)	0	0	0	0	0	0
Cementation (average) (%)	**0**	**0**	**0.2**	**0.2**	**0**	**0**

Appendix F1: Production Laboratory Ratings 2004

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
10	0	28.9	9	10		80
12	10	22.9	10	10	10	90
13	9	28.6	9	10	10	95
15	10	28.6	10	10	10	98
16	10	29.2	10	9	10	97
17	7	28.9	10	0		77
18	10	27.0	10	8	0	79
19	9	28.1	4	8	9	83
20	10	26.5	9	10		92
21	10	6.3	9	8		55
22	10	28.1	10	10	10	97
23	4	28.9	10	10	9	88
25	10	23.5	9	10	9	88
26	10	25.6	7	9	9	87
28	10	27.5	10	10	10	96
29	0	28.4	10	2		67
30	8	27.0	10	6	9	86
31	10	29.7	10	10	4	91
32	10	26.2	7	10	4	82
33	10	28.6	10	10	10	98
34	10	29.2	5	9	10	90
35	9	30.0	10	10	10	99
37	10	28.4	10	10	10	98
38	10	29.2	8	10	10	96
39	10	26.7	10	10	8	92
43	10	27.8	0	10	10	83
44	10	28.6	5	10		89
45	9	27.5	10	10	8	92
46	10	25.4	5	10	5	79
47	10	23.7	8	10	10	88
54	10	24.5	9	10	10	91
55	9	28.1	10	10	10	96
56	10	26.5	10	10	10	95
58	10	24.5	7	10	10	88
59	10	29.2	8	10	10	96
61	10	29.2	9	10	10	97

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
64	10	24.0	9	10	8	87
66	2	23.7	9	5	7	67
68	10	27.5	10	10	10	96
69	10	29.7	8	9	10	95
71	7	30.0	10	0	6	76
72	10	27.8	10	10		96
73	8	27.0	7	0	6	69
79	10	26.5	10	10	9	94
80	10	26.2	8	9	9	89
81	10	26.7	0	9	6	74
83	10	28.6	10	10	10	98
85	9	29.7	10	10	8	95
86	10	28.9	10	10	10	98
90	10	27.5	9	10	10	95
94	10	28.6	10	10	6	92
98	5	21.0	0	5	9	57
100	10	27.5	5	10	10	89
101	10	28.1	6	10	10	92
102	9	28.9	9	10	10	96
103	10	25.9	4	0	9	70
104	9	28.1	6	10	9	89
105	10	28.4	9	10		96
107	10	19.9	5	10	9	77
108	7	27.5	10	10	10	92
110	3	25.4	10	9	9	81
112	10	25.6	10	9	10	92
113	10	24.5	7	10	0	74
114	10	28.4	10	8	10	95
115	9	23.7	10	10	10	90
116	2	29.5	10	9	8	84
117	10	24.5	10	10	10	92
120	10	29.5	10	5	6	86
123	9	28.1	9	10	10	94
124	5	27.3	10	9	10	88
126	9	29.7	6	9		90
127	10	30.0	10	10	10	100
128	9	24.3	10	10	10	90
129	10	27.5	10	10	10	96
134	10	27.5	10	10	10	96
136	10	25.4	10	10	10	93
137	10	28.4	10	10	7	93
138	10	27.3	10	10	6	90

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
139	9	28.9	10	9		95
141	7	29.7	9	10	10	94
144	9	21.5	8	10	10	84
145	0	24.8	10	0	5	57
146	10	26.5	10	10	7	91
147	10	27.0	9	10		93
148	8	27.3	8	10	6	85
153	10	26.5	5	10	0	74
157	10	30.0	10	10	8	97
158	9	20.2	10	10	6	79
161	10	28.4	5	9		87
163	7	27.0	8	8		83
164	10	28.9	10	8	10	96
167	0	20.2	10	9	10	70
169	0	28.9	0	10	10	70
172	7	29.7	10	10	10	95
175	10	28.4	3	5	10	81
176	0	27.0	9	10		77
177	10	26.5	10	10	10	95
178	10	29.5	8	10	10	96
179	10	25.1	10	10	10	93
180	10	25.4	10	9	10	92
181	10	28.9	5	4	10	83
182	10	27.3	9	8	10	92
184	8	28.6	8	9	6	85
186	10	26.2	8	10	10	92
187	10	24.3	9	9	8	86
188	10	30.0	10	10	10	100
189	10	26.5	10	10	5	88
191	10	29.7	7	10	9	94
193	10	25.4	10	10	10	93
194	10	27.8	10	2	9	84
197	10	27.0	10	10		95
198	10	29.5	7	10	3	85
199	10	30.0	10	10	10	100
200	10	28.6	10	9	7	92
201	10	25.9	10	10		93
202	10	29.5	10	10		99
204	10	28.9	10	9	3	87
205	9	26.2	10	10	8	90
208	8	24.0	0	9	7	69
210	4	22.1	10	7		72

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
212	10	27.8	8	10	9	93
214	10	30.0	8	10	6	91
215	10	29.2	9	10	9	96
216	10	12.5	10	10	10	75
217	9	24.5	8	10		86
218	8	20.7	9	10	6	77
219	4	28.9	9	1	10	76
221	10	28.9	9	9	9	94
223	10	30.0	6	7		88
224	9	27.8	10	9	10	94
228	5	30.0	7	10	8	86
230	10	29.7	9	10	10	98
232	9	29.7	5	6	7	81
234	10	21.0	8	10	10	84
235	9	30.0	10	9	5	90
236	10	27.8	10	7	9	91
237	10	26.2	6	10		87
242	10	24.8	9	10		90
245	3	29.2	10	10	10	89
246	10	25.6	10	10	10	94
247	10	23.7	10	10	10	91
248	10	26.2	10	10	10	95
249	10	26.5	10	10	10	95
250	10	22.6	10	10	10	89
251	10	28.6	10	10	10	98
252	10	26.5	10	10		94
253	10	25.1	7	10	9	87
254	1	30.0	8	10	10	84
255	10	27.8	0	8	9	78
256	10	26.7	9	8	9	90
257	10	28.6	6	10		91
258	6	28.1	10	10	10	92
259	10	25.6	9	7	10	88
260	10	29.5	9	10	10	98
262	5	20.7	0	2	4	45
263	10	29.7	10	10	8	97
264	10	29.5	10	10	10	99
269	10	28.9	10	5		90
271	10	29.2	10	10	10	99
272	9	29.5	10	8	6	89
273	10	24.3	9	9	7	85
274	10	27.0	10	0	10	81

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
275	8	22.9	10	10	9	86
276	10	27.8	10	10	10	97
277	9	24.3	8	7	8	80
278	10	27.0	1	10	10	83
279	9	29.2	9	10	10	96
280	8	26.2	3	10	10	82
284	10	28.1	10	10	10	97
285	10	19.9	10	9	10	84
287	10	24.0	7	10		85
288	10	22.9	0	8	10	73
290	10	28.1	10	7	10	93
291	6	28.6	10	7	0	74
292	10	19.6	2	10	9	72
293	10	26.2	10	10		94
294	10	28.1	10	8	10	94
295	10	29.5	7	10	10	95
296	10	27.8	2	10		83
297	10	27.8	10	10	7	93
299	10	29.5	10	10	10	99
300	9	29.7	10	10	7	94
301	8	29.5	10	10	10	96
302	10	27.3	9	9	10	93
303	8	29.2	8	10	3	83
305	10	28.6	8	10		94
306	6	28.6	9	10	9	89
307	9	27.3	0	10		77
308	10	27.0	10	10		95
309	10	28.1	9	10	9	94
311	9	28.1	10	10	10	96
312	10	25.4	10	10	10	93
313	8	27.8	10	10		93
314	10	28.9	10	10		98
315	10	28.1	10	10	10	97
318	9	27.8	8	10	5	85
319	10	28.6	10	10		98
320	8	22.9	10	4		75
321	8	26.5	10	10	8	89
323	9	23.7	10	8	10	87

Appendix F2: Full Service Aggregate Laboratory Ratings 2004

FULL SERVICE AGGREGATE LABORATORY RATINGS 2004

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-606 $MgSO_4$ (FA)	LS-623 One Point Proctor	LS-619 MDA (FA)	Rating
13	9	28.6		10	10	9	10	10	9	10	10	10	10.0	9	96
15	10	28.6		10	9	10	10	10	10	10	6.5	10	10.0	9	95
18	10	27.0		9.5	10	10	8	0	8	7	10	9	10.0	10	86
19	9	28.1		10		4	8	9	10	10	9.5		9.3	8	88
22	10	28.1		10		10	10	10	10	10	10		10.0	10	99
23	4	28.9		9.5	9	10	10	9	9	10	9.5	10	8.7	10	92
28	10	27.5		9		10	10	10	6	8	9.5		7.0	5	86
31	10	29.7	10	10	10	10	10	4	10	10	6.5	4	8.7	8	88
35	9	30.0	2	10	10	10	10	10	10	10	9.5	4	10.0	9	90
37	10	28.4	10	9	10	10	10	10	10	10	10	10	10.0	10	98
38	10	29.2	8	10	10	8	10	10	8	9	8	8	7.7	10	91
46	10	25.4		10	10	5	10	5	7	6	10	10	9.3	10	85
47	10	23.7	10	10	8	8	10	10	10	10	10	10	10.0	10	94
56	10	26.5	10	10	10	10	10	10	10	2	10	10	10.0	10	93
59	10	29.2		9	10	8	10	10	10	10	10	8	10.0	8	95
61	10	29.2		10	10	9	10	10	10	10	10	10	8.7	7	96
69	10	29.7		10		8	9	10	7	7	0		8.3	9	83
79	10	26.5		10		10	10	9	9	10	10		10.0	10	96
80	10	26.2	8	5	7	8	9	9	10	10	4	8	10.0	8	83
83	10	28.6		7		10	10	10	9	10	9.5		9.0	6	92
86	10	28.9		9.5		10	10	10	9	9	7		10.0	8	93
100	10	27.5		10	10	5	10	10	10	10	9.5			10	94
101	10	28.1	10	7.5	10	6	10	10	9	10	9.5	10	9.0	9	93

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-606 $MgSO_4$ (FA)	LS-623 One Point Proctor	LS-619 MDA (FA)	Rating
107	10	19.9		5	10	5	10	9	10	6	10	10		10	82
108	7	27.5		8	7	10	10	10	3	10	10	9	0	10	81
110	3	25.4		9		10	9	9	9	10	10			8	85
112	10	25.6		10	2	10	9	10	10	6	10	10	10.0	9	88
123	9	28.1		7.5	9	9	10	10	9	10	9	9	5.7	9	90
124	5	27.3		10		10	9	10	10	10	10		10.0	8	92
157	10	30.0		10	10	10	10	8	9	9	8.5	10		10	96
164	10	28.9		10	10	10	8	10	5	10	10	9		10	94
172	7	29.7		3	10	10	10	10	6	10	10	10	7.0	8	87
188	10	30.0	8	8.5	10	10	10	10	9	10	10	8	10.0	10	96
199	10	30.0		10		10	10	10	8	10	10		1.0	10	92
205	9	26.2		10		10	10	8	10	10	10		10.0	10	95
214	10	30.0		9		8	10	6	8	7	10			10	90
216	10	12.5		10	7	10	10	10	10	9	9.5	10	9.0	9	84
245	3	29.2		10		10	10	10	9	7	9.5		5.3	10	87
260	10	29.5		9.5	8	9	10	10	0	4	9	10	10.0	9	85
263	10	29.7		9.5	10	10	10	8	9	10	8.5	10	10.0	8	95
285	10	19.9		8	9	10	9	10	10	7	9.5		10.0	9	87
295	10	29.5		10	10	7	10	10	8	10	10	10	9.7	9	95
301	8	29.5		9.5	7	10	10	10	7	10	10	10	9.0	7	91
306	6	28.6		10		9	10	9	10	5	10		9.0	9	89

Appendix F3: Soil Laboratory Ratings 2004

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
12	10.0	4.7	5	66
15	9.2	8.3	10	92
18	9.8	9.3	10	97
19	7.6	8.7	10	88
20	5.6	7.3	10	76
22	9.4	9.3	9	92
23	8.6	10.0	0	62
28	9.0	8.3	9	88
29	9.8	9.7	8	92
30	4.2	8.7	8	70
31	9.4	4.0	10	78
32	9.8	6.3	8	80
34	10.0	9.0	5	80
35	9.6	6.7	10	88
37	9.2	10.0	9	94
38	9.4	8.7	10	94
44	9.6	9.0	10	95
46	9.0	9.0	10	93
47	6.6	9.3	8	80
54	7.2	10.0	10	91
56	8.0	10.0	0	60
58	10.0	9.7	10	99
59	10.0	9.0	9	93
64	9.8	8.3	10	94
66	9.4	9.3	9	92
68	10.0	9.7	10	99
69	8.8	10.0	6	83
71	9.8	9.0	9	93
72	10.0	10.0	7	90
79	9.8	9.7	10	98
80	9.2	10.0	9	94
83	8.8	10.0	9	93
86	6.8	10.0	9	86
94	8.8	9.7	10	95
98	0.0	9.7	0	32
101	5.6	10.0	0	52
102	10.0	10.0	8	93
108	0.0	4.7	0	16

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
112	9.8	9.3	10	97
120	9.8	6.7	10	88
138	8.6	9.3	0	60
146	9.8	8.7	10	95
148	7.0	8.7	0	52
172	10.0	10.0	9	97
188	9.0	10.0	9	93
208	10.0	10.0	10	100
210	9.4	6.0	10	85
216	8.2	9.0	10	91
253	5.8	9.3	9	80
260	8.2	9.0	6	77
276	10.0	7.3	0	58
284	2.8	9.3	9	70
285	9.8	9.3	10	97
292	9.4	7.3	10	89
299	9.0	9.3	9	91
300	10.0	9.7	0	66
301	7.6	9.7	10	91
306	5.8	8.3	2	54

Appendix F4: Superpave Laboratory Ratings 2004

Laboratory No.	C 1252/T304 Uncompacted Void Content	D 2419/T176 Sand Equivalent	ASTM D 5821 % Fractured Particles	ASTM D 4719 % Flat & Elongated	Rating
13	6	7	9	5	68
15	10	10	9	10	98
19	10	9	7	9	88
22	10	8	10	10	95
26	9	10	9	8	90
31	10	10	10	7	93
33	10	8	10	9	93
35	9	9	7	10	88
37	10	10	10	6	90
39	10	10	9	9	95
43	10	10	9	10	98
47	10	8	4	7	73
56	10	10	9	10	98
58	10	8	10	10	95
59	10	7	10	7	85
61	10	9	9	8	90
69	8	10	7	10	88
71	4	10	10	10	85
79	7	10	10	2	73
80	10	8	8	10	90
83	9	10	9	10	95
86	8	6	10	10	85
100	8	8	8	9	83
112	10	10	10	10	100
120	8	10	10	8	90
123	2	8	10	10	75
124	9	8	10	10	93
157	10	10	10	10	100
186	8	10	10	9	93
188	10	9	10	10	98

Laboratory No.	C 1252/T304 Uncompacted Void Content	D 2419/T176 Sand Equivalent	ASTM D 5821 % Fractured Particles	ASTM D 4719 % Flat & Elongated	Rating
216	10	7	5	6	70
235	3	10	9	9	78
236	0	8	9	0	43
245	0	10	10	10	75
263	10	8	8	8	85
272	10	10	7	10	93
285	10	10	9	9	95
294	10	10	10	10	100